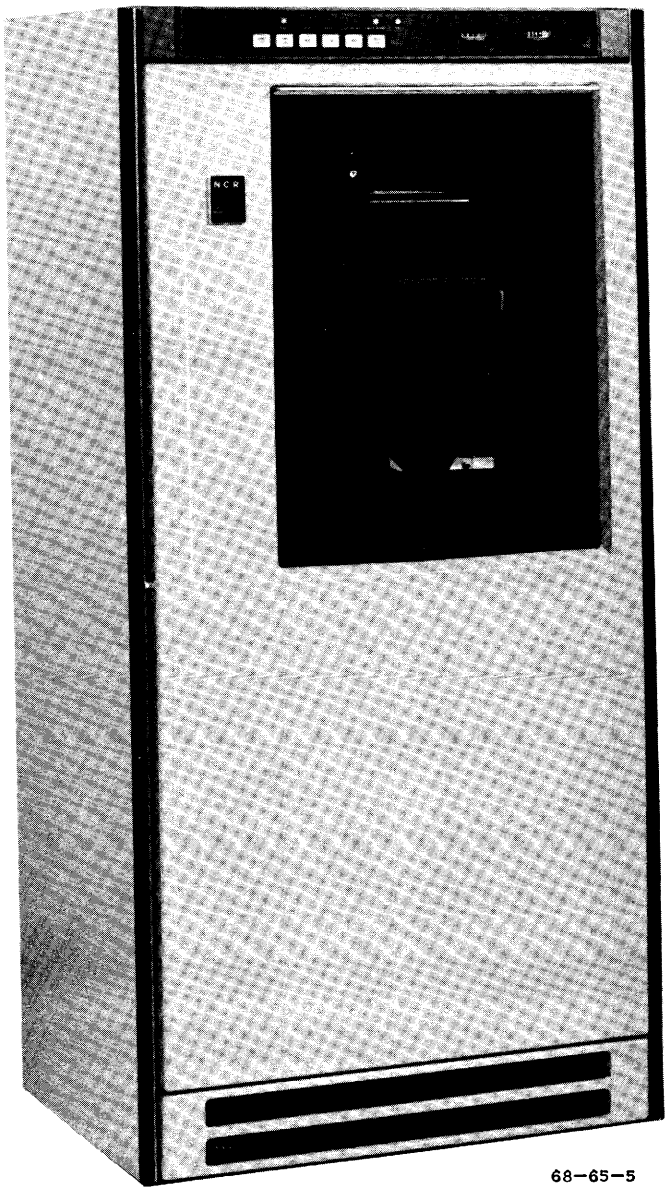
653 CRAM UNIT



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This publication is a functional hardware description of NCR's Century Series CRAM (Card Random Access Memory) unit. A separate publication in this series (ST-9402-39) contains a functional description of model 623-101 CRAM Control Unit. While the information contained in this publication may be helpful to the programmer and operator, it is not intended as a substitute for NCR Century programming or operating manuals.

TABLE OF CONTENTS

INTRODUCTION 4

PHYSICAL DESCRIPTION

UNIT DESCRIPTION 5

- Magazine Assembly 6
- Capstan 10
- Release Gate 11
- Read/Write Head Assembly 12
- Raceway 14
- Loader Assembly 15

MEDIA DESCRIPTION 19

- CRAM Media Characteristics 19

FUNCTIONAL DESCRIPTION

I/O REQUIREMENTS 21

SELECTION 21

- INOUT Command 21
- Peripheral Address Field (PAF) 22
- Function Codes 23
- S2 Status 24
- Selection Phase Summary 25

DATA TRANSFER 26

- Response Number 26
- Control Word (CW) 27

TERMINATION 28

- S3 Status 28
- S3 Status Character Timing 29
- S4 Status 29
- Data Transfer and Termination Phase Summary 29

SPECIFICATIONS

PHYSICAL SPECIFICATIONS 31

ENVIRONMENTAL SPECIFICATIONS 31

OPERATION

CONTROL PANEL 32

POWERING UP THE CRAM UNIT 35

POWERING DOWN THE CRAM UNIT 35

LOADING A CRAM DECK 36

CHANGING CRAM DECKS IN A CRAM UNIT 38

CRAM DECK MAINTENANCE 41

Inspection of Tabs 41
Inspection of Surface 43
Operation Procedures 44
CRAM Card Coding Procedure 44

UNIT MAINTENANCE 48

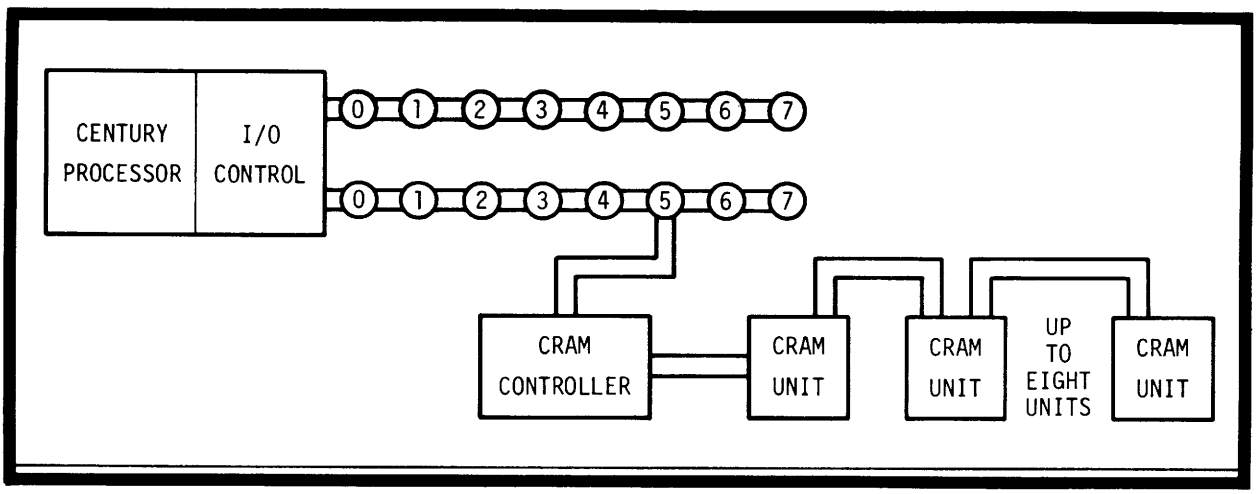
Normal Operator Maintenance 48
Emergency Operator Maintenance (Jams) 50

INTRODUCTION

The word CRAM (Card Random Access Memory) designates the method of storage and retrieval used by the CRAM unit. CRAM is ideally suited for random access magnetic file storage applications because of its mass storage capabilities (145,041,408 characters per deck) and the rapid accessing of each magnetic card (average 100 to 125 milliseconds card drop time). CRAM storage combines many of the advantages of magnetic tape and disc units.

The mass storage medium is a deck of 384 flexible magnetic cards. A cartridge containing a deck of cards can be quickly removed from the CRAM unit, replaced by another cartridge, stored offline, and readily reinserted when needed.

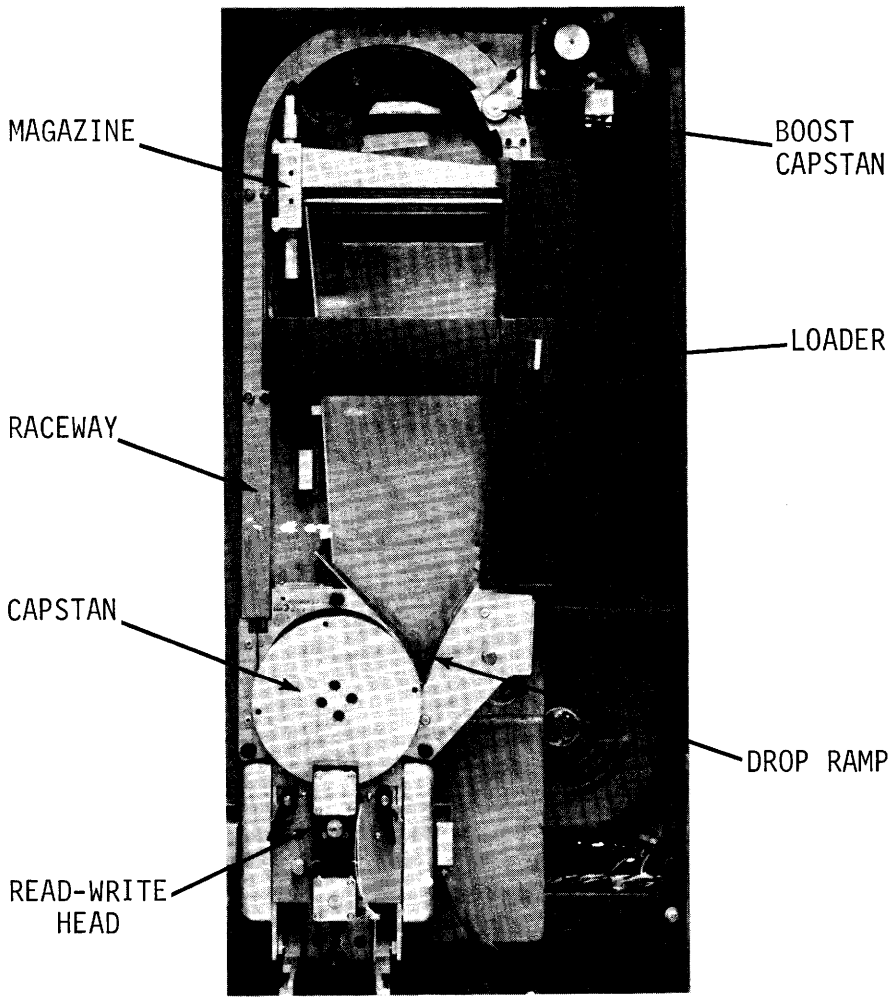
As many as eight CRAM units can be connected to any free common trunk position through a 623-101 CRAM control unit. The only restrictions on the number of control units and associated CRAM units are the number of free positions for the particular system and the requirements of the particular application.



PHYSICAL DESCRIPTION

UNIT DESCRIPTION

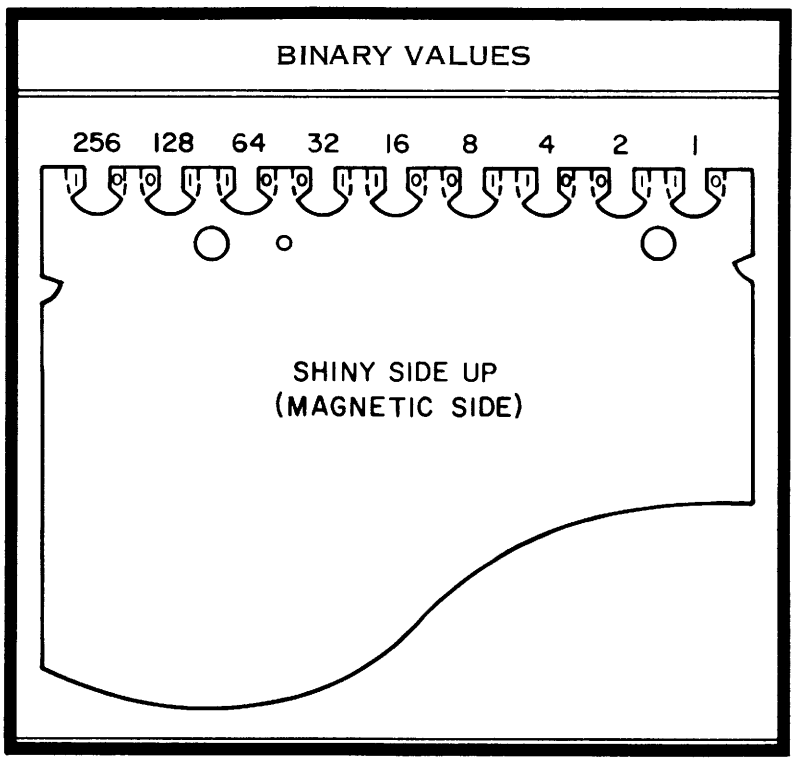
The main physical components that comprise the card handling mechanisms of the CRAM unit are the magazine assembly, capstan, read/write head assembly, release gate, and the raceway.



The basic operations of the CRAM unit are to select a single magnetic card from 384 cards held in the magazine assembly, transport this card over the read/write heads at a speed of 380 inches per second for the required number of revolutions, and return the card to the magazine assembly.

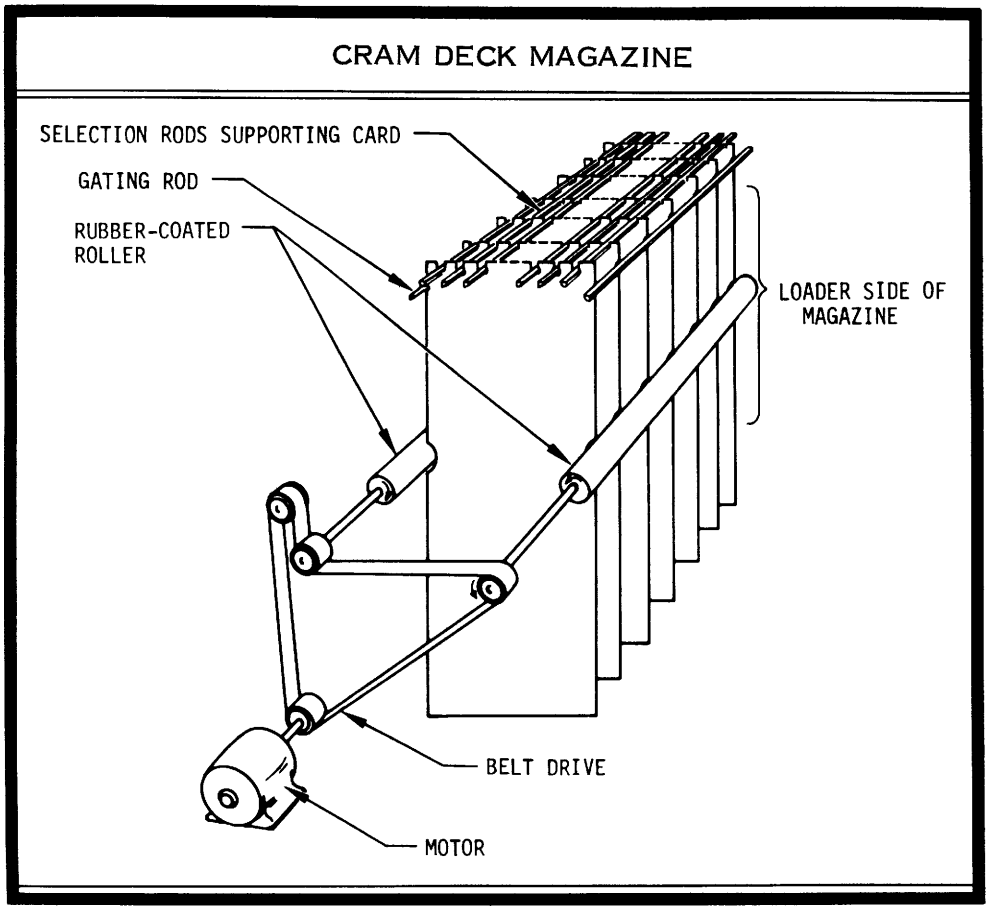
Magazine Assembly

A series of nine notches, located along the top edge of each card, are used for binary coding of the card number.

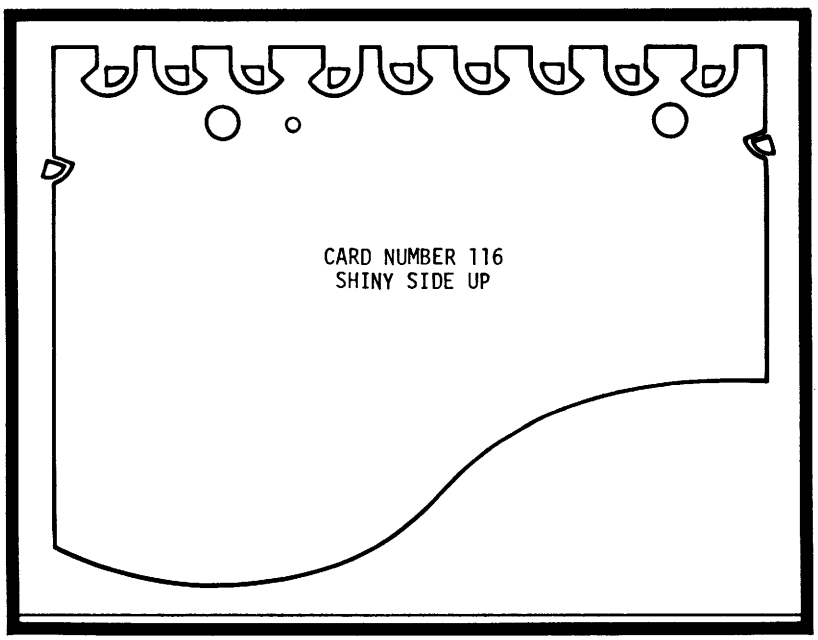


Each notch has a flange on one side (representing a binary 0) or the other (representing a binary 1). There are 512 configurations for the nine notches ranging from 000000000 to 111111111 (decimally 000 through 511) but only 384 cards are used. The 1 and 0 shown on the flanges of the preceding figure represent binary one and binary zero codes for each numbered notch. The decimal number of the card is determined by adding the values of the notches in which the binary one flanges have been removed. One flange for each notch has to be removed. If both flanges are removed, the card number is in error and two cards may drop.

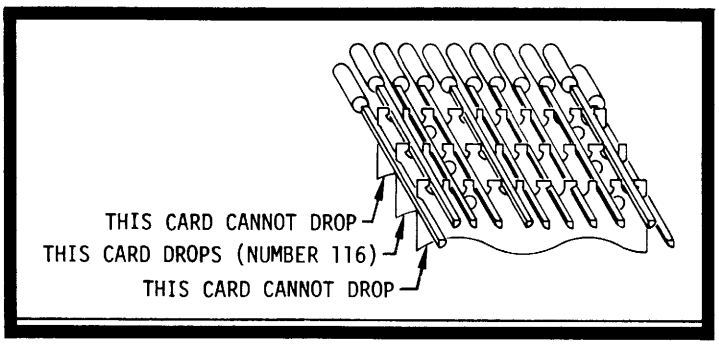
Nine selection rods pass through the nine notches in the card. A deck of cards in the CRAM hangs from the nine selecting rods and two gating rods.



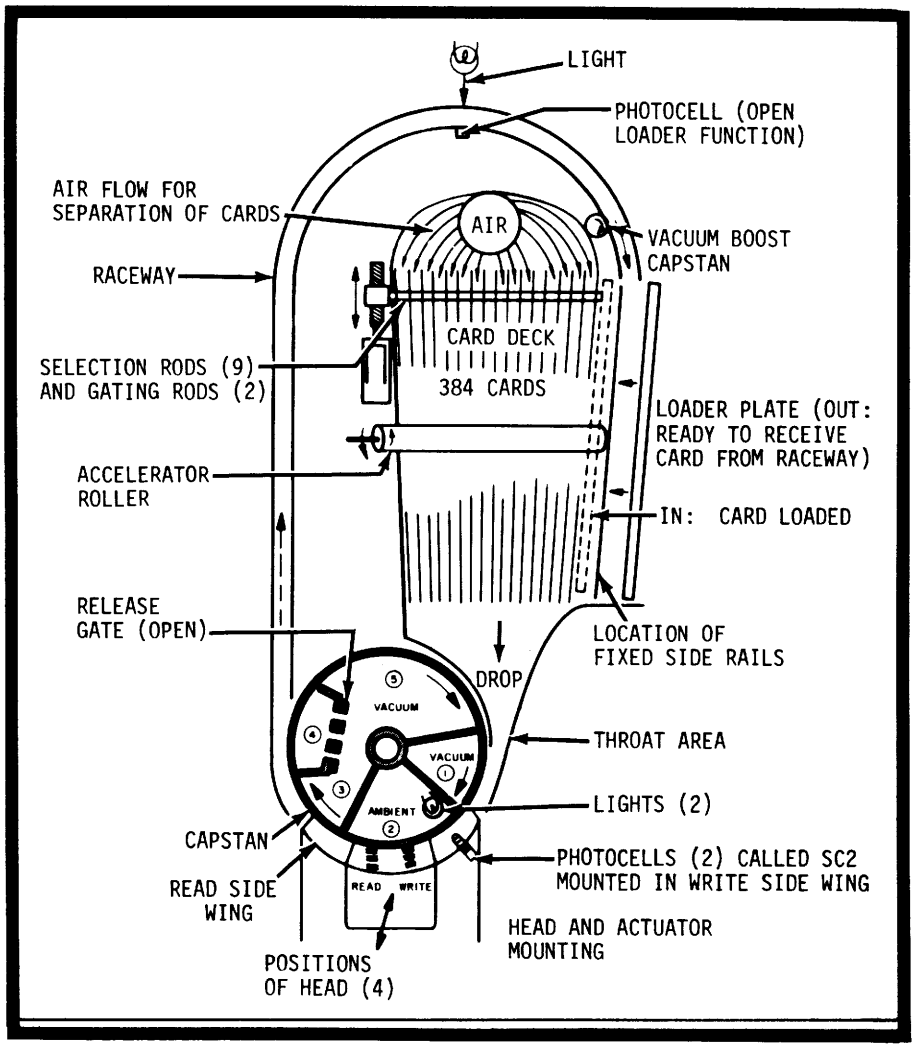
The processor calls for a card by number. The CRAM control unit transmits this number to the selected CRAM unit. The selection rods rotate to the positions which correspond to that number.



Gating rods fit into notches on each side of the cards to support the entire deck while the selection rods are rotating. The specified card is held by the gating rods only, once the selection rods attain the correct binary position.



The gating rods rotate, releasing the card, which is accelerated by two speed-up rollers within the magazine. The card descends through the drop and shroud ramps and adheres to the capstan, a small high-speed rotating drum.



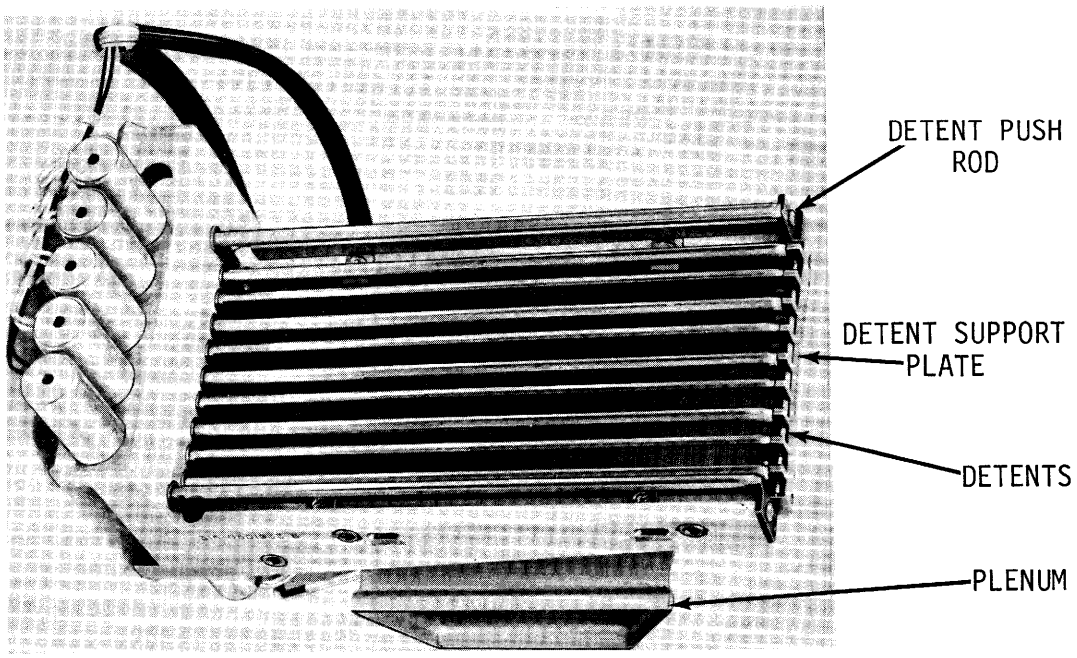
The remaining cards in the deck are held by the selection rods.

Air is supplied through the plenum to the air separator just above the selection rods. The air from the plenum spreads the cards across the width of the magazine and separates each card from the adjacent card by a flow of air. A flow of air is also provided on the left side of the magazine between the cards and the magazine cover plate.

If a card does not reach the capstan 0.75 seconds after the gating rods rotate to release the card, the card is considered a hanger and the CRAM is inoperative until the operator intervenes. A hanger condition can be caused if the selected card is missing or damaged so that it will not fall freely.

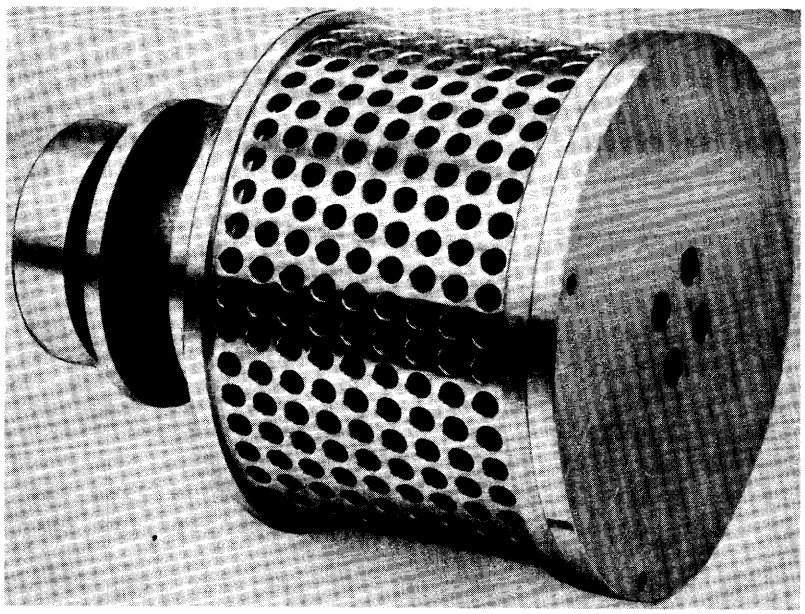
If a card number greater than 383 and less than 512 is requested, no card is dropped (provided there is not an illegally coded card in the deck) and a hanger condition results. If a card number greater than 511 is requested, a card drops according to the modulo 512 of the card number, i.e., select card 512 and card 000 will drop.

A detent assembly is located at the right end of the selection rods. The detents hang down by their own weight into the path of the cards to prevent their coming off the right side of the selection rods when the loader is open. The assembly offers no opposition to the card being placed on the selection rods.

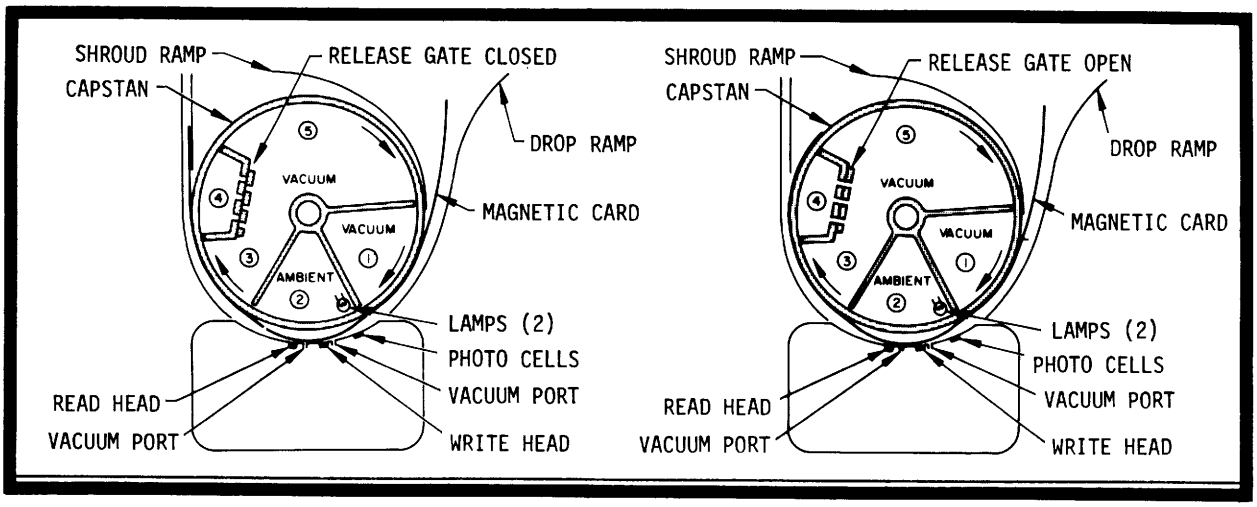


Capstan

The function of the capstan is to transport the card across the read-write head at a constant speed of 380 inches per second.



The capstan assembly consists of a revolving aluminum cylinder and an inner stationary air chamber. The air chamber has three cavities with a release gate assembled in the largest cavity. There are five areas of the capstan that have either vacuum or ambient pressure.



The first area of the capstan that the card reaches after it is dropped is adjacent to a section of the air chamber where a vacuum is produced. When the card reaches this area the vacuum pulls the leading edge against the capstan causing the card to accelerate to the speed of the capstan. The vacuum

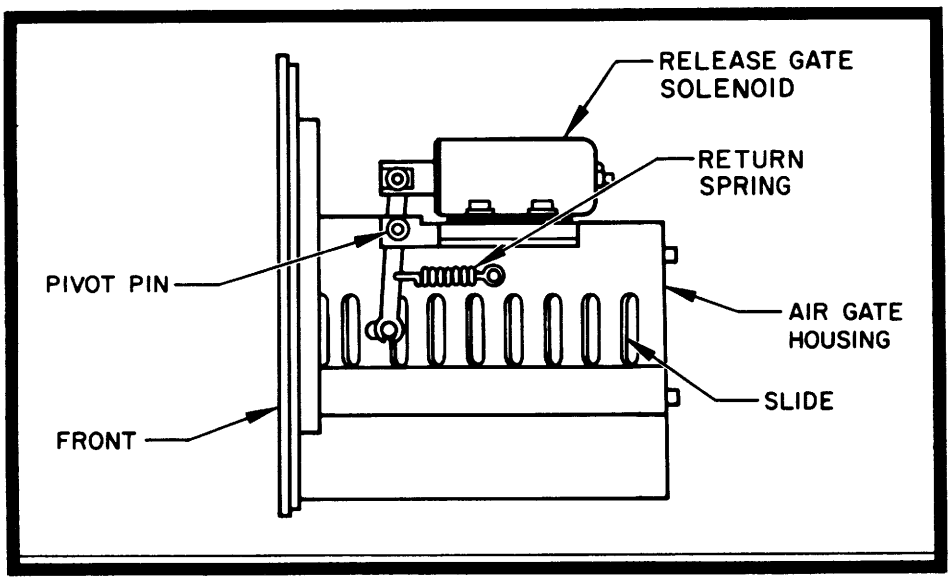
area extends to area 2, above the read/write head. This area of the capstan is open to ambient pressure, which allows the vacuum from within the head to pull the card against the head area for better contact during reading or writing. The card next reaches area 3 where the vacuum again pulls the card to the capstan. At area 4 (the release gate) there is vacuum or ambient pressure depending on whether the card is to be released or held on the capstan. If the card is to be released the release gate will be closed shutting area 4 off from the vacuum and allowing the card to enter the raceway. If the card is to stay on the capstan the release gate will be open to the vacuum and the card will be held against the capstan. It will also be held to the capstan in area 5.

Release Gate

The selected card stays on the capstan until one of four things happens:

- A seek command is given for a different card.
- A release command is given.
- A read command is given for a different card.
- The emergency release timer times out. The timer will time out about 0.75 seconds after the last command is executed on this unit.

The emergency release timer prevents unnecessary card wear. To minimize wear, software should provide for the release of the card immediately when a read or write function is completed unless another read or write function is required for the same card.

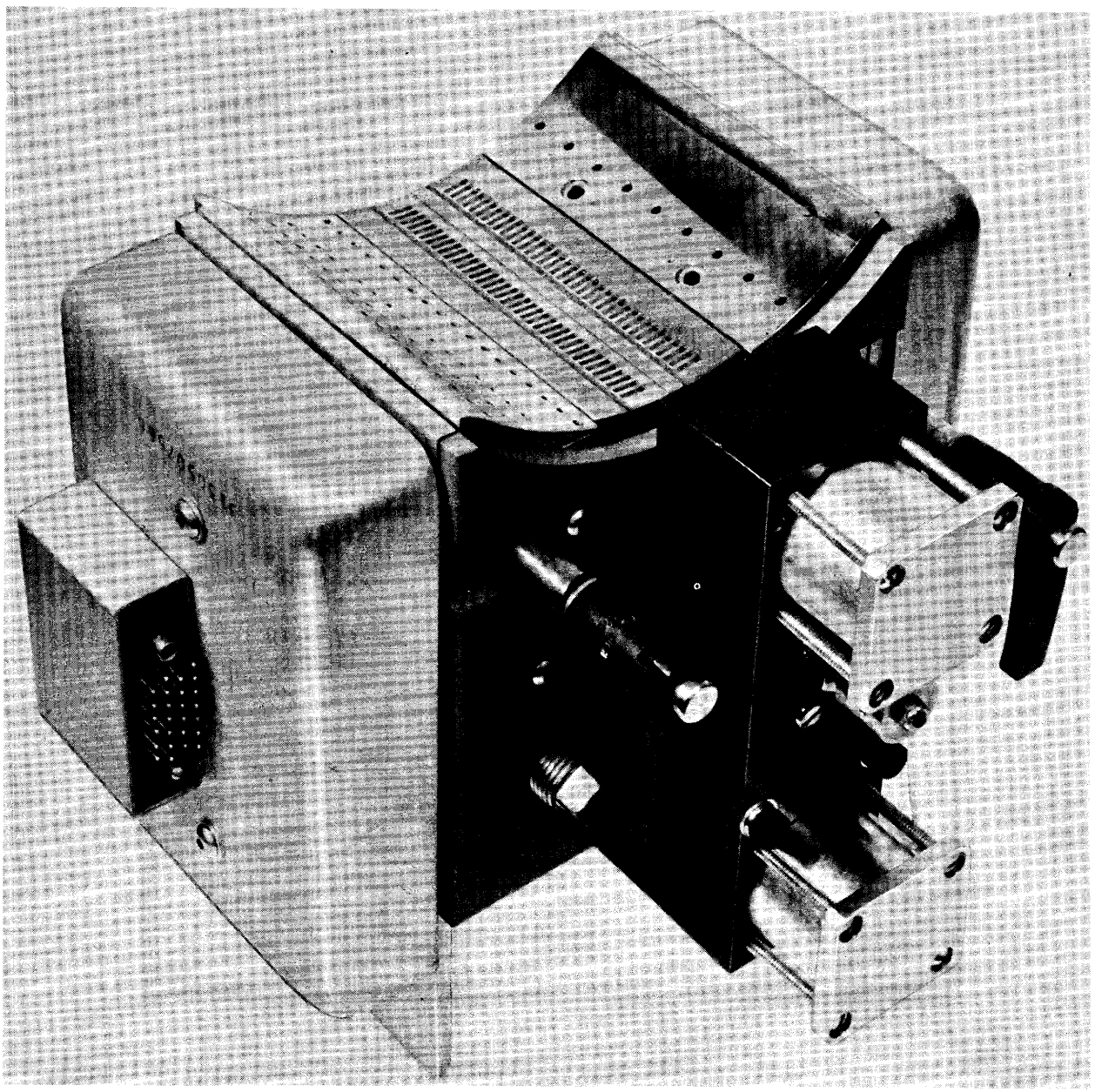


During the time the card is held on the capstan, the release gate solenoid will be pulled up holding the slide to the front. In this position the openings in the slide and the air gate housing will line up, opening the release gate area to vacuum so the card will stay on the capstan. When the card is to be released, the release gate solenoid will relax allowing the slide return

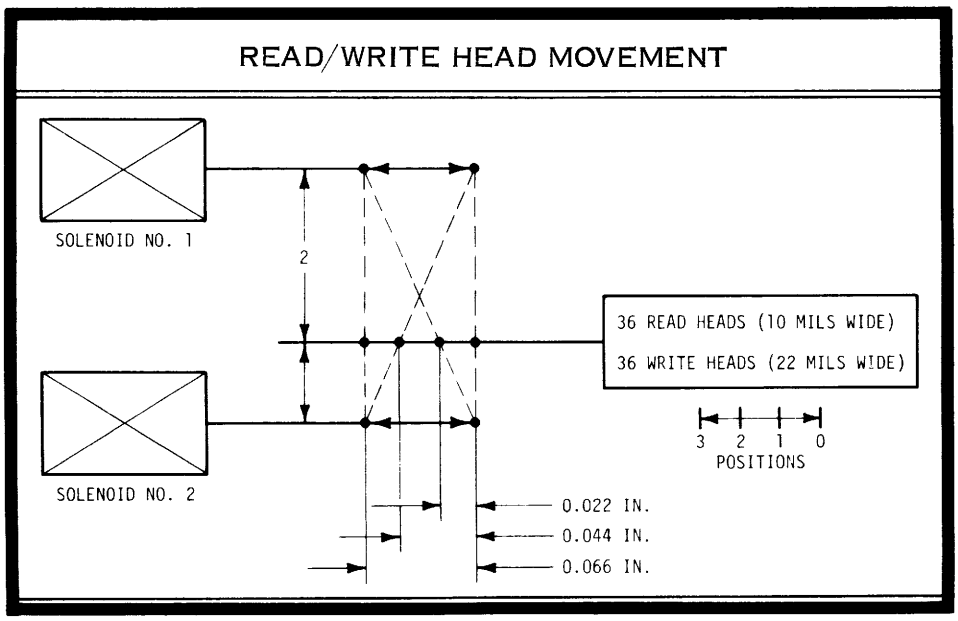
spring to pull the slide to the back. This will close the openings of the air gate housing, shutting this area off from the vacuum and allowing the card to leave the capstan and enter the raceway.

Read/Write Head Assembly

There are 144 data tracks on a 653-101 CRAM card. They are numbered 0-143 but are interlaced as four groups of 36. Reading or writing is done by a movable read/write head.



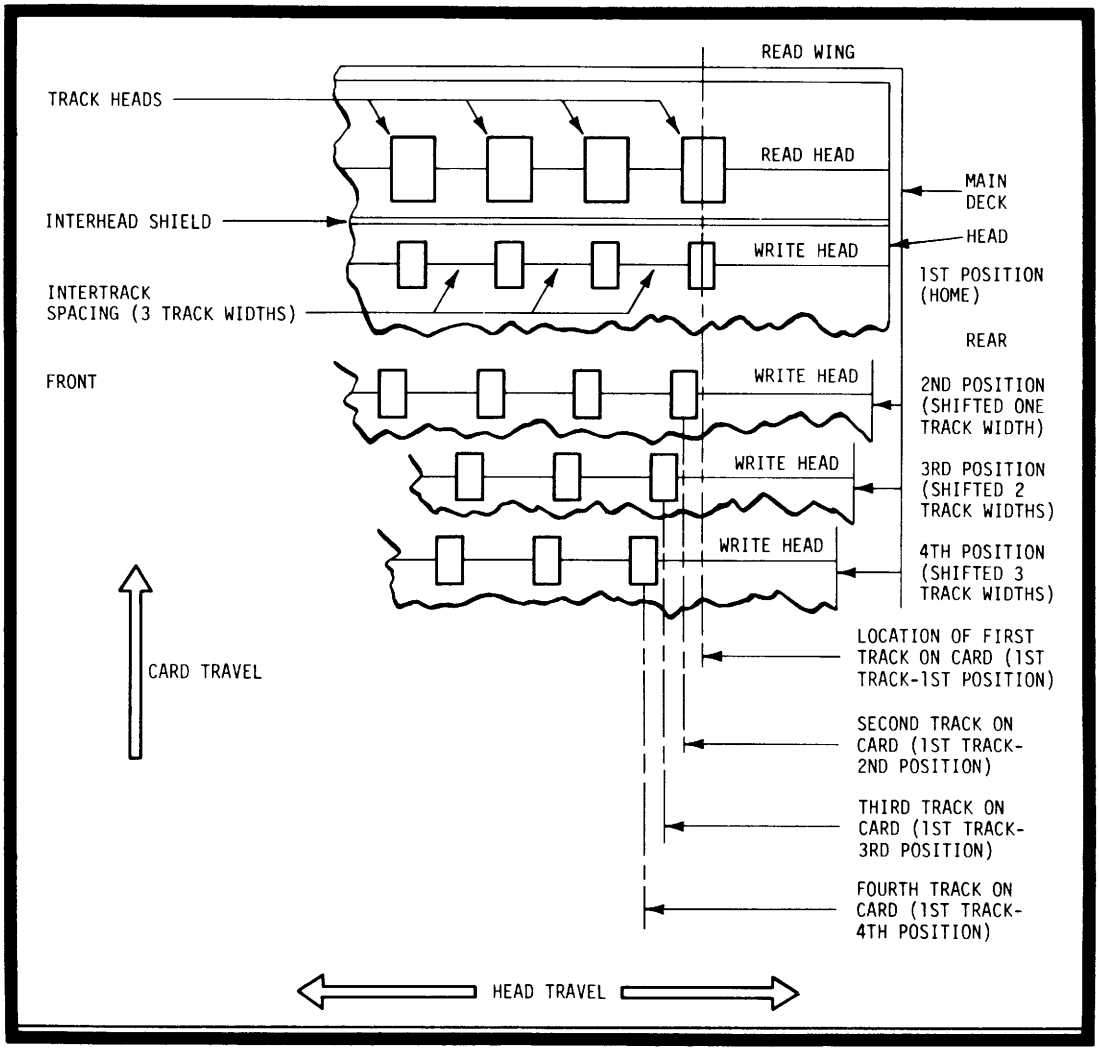
There are 36 read heads and 36 write heads in the read/write head assembly. The assembly may be moved to any one of four positions.



At each position the assembly is set to read or write on any one of 36 data tracks. The head must be repositioned to use the next 36 tracks.

The time to move the head to any track group will be less than 40 milliseconds. The head will be positioned to the selected track while a card is falling. If the card is already on the capstan, the head is positioned while the card remains on the capstan.

The following figure illustrates head movement in the 653-101 CRAM. The entire head assembly shifts, moving the 36 write heads and 36 read heads to any one of four positions. At each position, one group of 36 tracks is covered and one track can be written on or read.

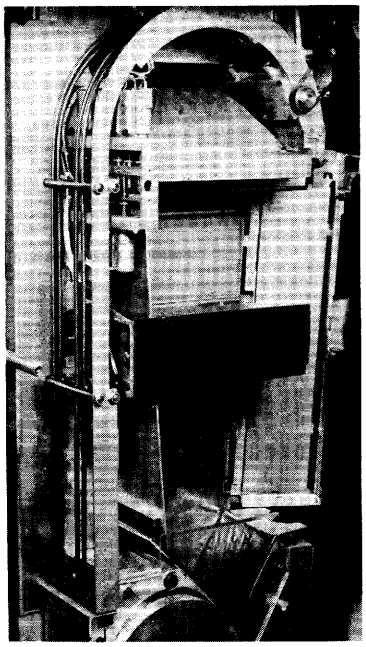


When the leading edge of the CRAM card covers the two photoelectric cells in the head assembly a signal is sent indicating that the card is in the minimum access area (nearing the position where reading or writing will begin). The signal is sent when the leading edge of the card is half way between the read and write heads. If the controller has not received a character from the processor by this time, an error condition results indicating the CRAM unit did not receive a character in time to write.

Raceway

When the release gate is closed, the card will enter the raceway. The inertia of the card will carry it up the raceway to the archway. In the lower right side of the archway the card receives a boost from the boost capstan so that it enters the loader area at a constant speed.

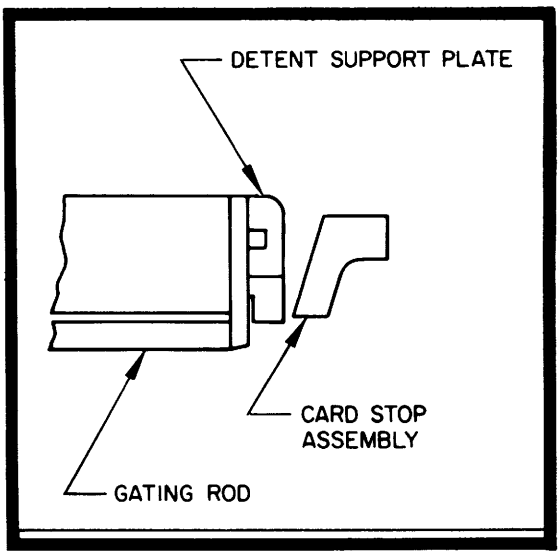
As the card passes over the archway, the loader mechanism will be actuated and the loader plate will open allowing the card to enter the loader.



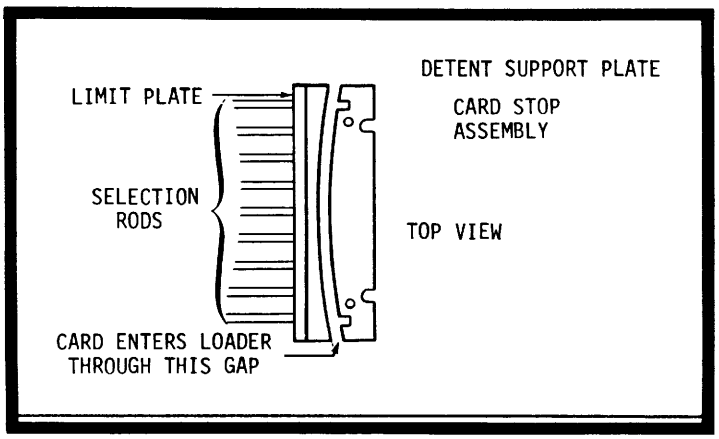
Loader Assembly

The function of the loader assembly is to receive the card from the archway and load it on the selection and gating rods.

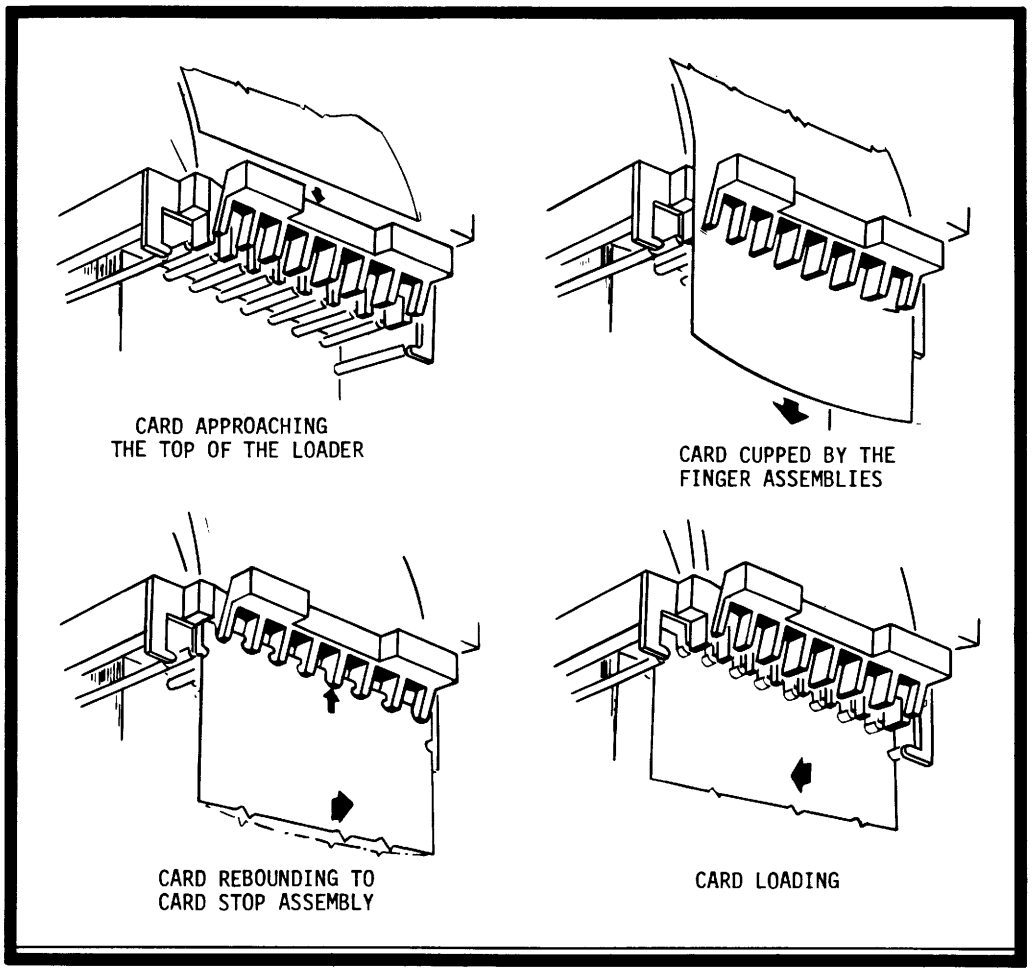
When the card covers the photoelectric cell in the archway, a solenoid energizes, moving the loader plate to the right from its normal position and out of the path of the incoming card. The card enters the loader through a gap between the card stop pawl (lower extension of the archway) and the detent support plate, which is mounted on the right end of the magazine assembly.



The gap is curved, causing the card to be cupped (the center is 1/16 inch further to the left than the outside edges) as it goes through the gap.

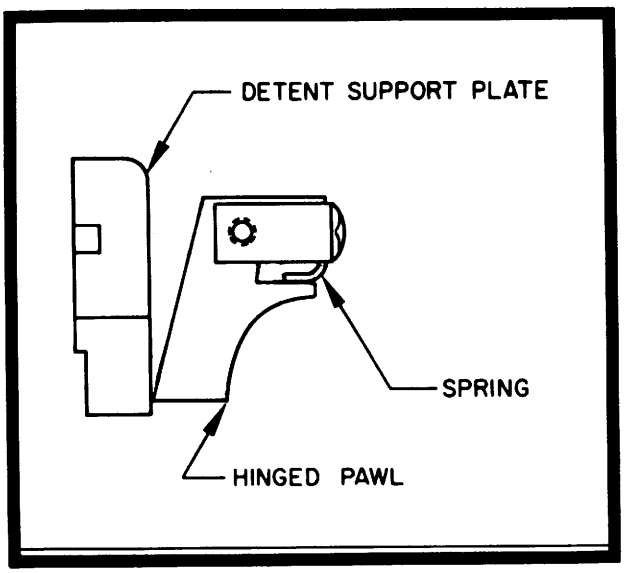


The detent support plate has nine fingers that extend down. They are at the right end of the nine selection rods. The card stop pawl has nine fingers that extend down matching the fingers of the support plate.


CARD APPROACHING THE TOP OF THE LOADER
CARD CUPPED BY THE FINGER ASSEMBLIES
CARD REBOUNDING TO CARD STOP ASSEMBLY
CARD LOADING

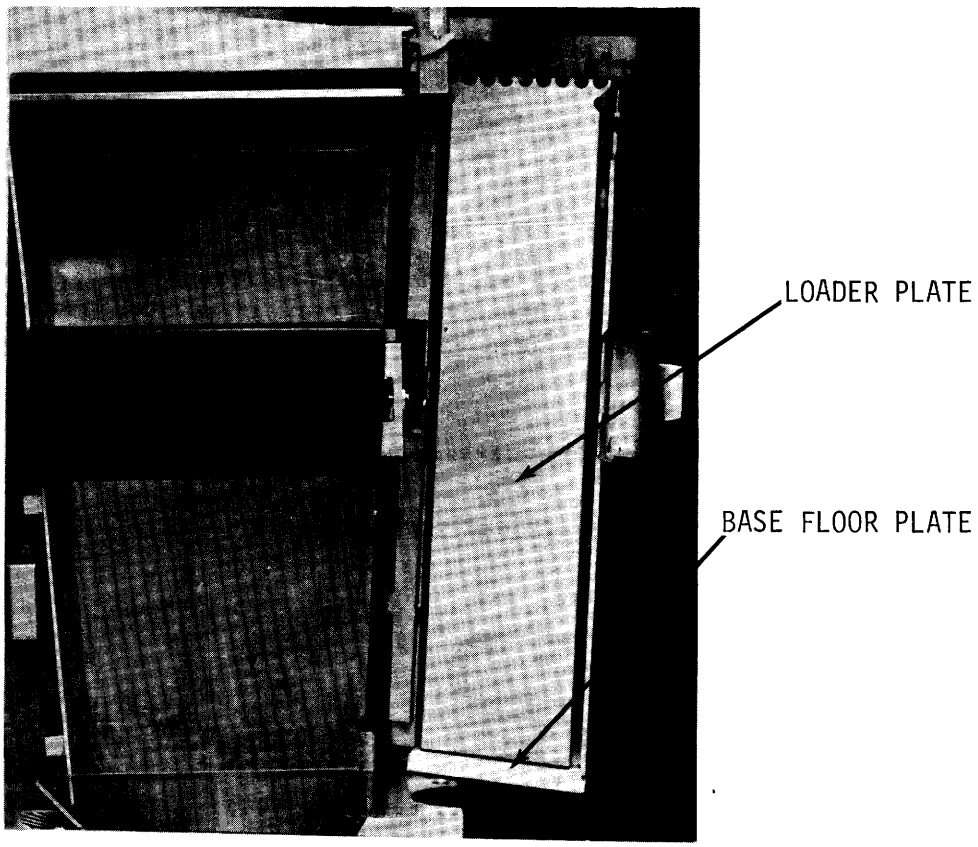
As the card comes down in the loader, it is guided by the loader plate and a groove in each side of the loader. As the trailing edge of the card comes out of the gap, it clears the card stop pawl and the curve in the card begins to straighten. The card is stopped when it reaches the base floor plate. The card is prevented from rebounding back up into the archway because the curve in the card has straightened; the card rebounds against the fingers of the card stop pawl.

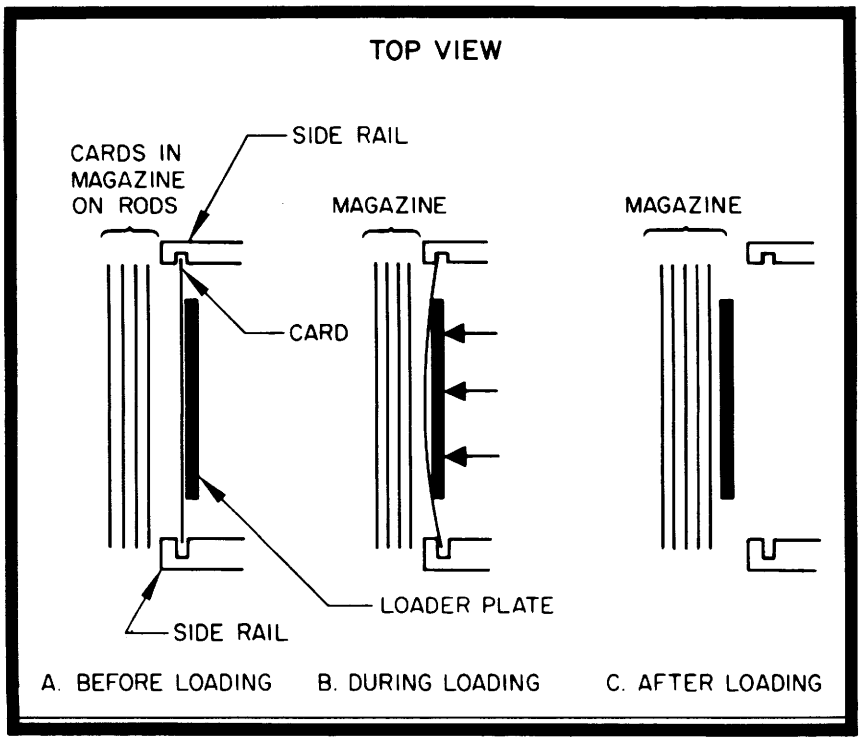
There is also another method used to prevent the card from rebounding back up in the archway. The two outside fingers of the card stop pawl are hinged. The bottoms of the two fingers are held by spring tension against the two outside fingers of the support plate.



When the card comes through the gap, it flexes the two fingers out of its path. When the card clears the fingers, they move back against the fingers of the support plate, closing the gap and preventing the card from rebounding into the archway.

When the trailing edge of the card uncovers the photoelectric cell, electronics are triggered to start closing the loader after a delay. This gives the card time to settle to the base floor plate. The closing of the loader plate assembly is initiated by the energizing of the load solenoid.

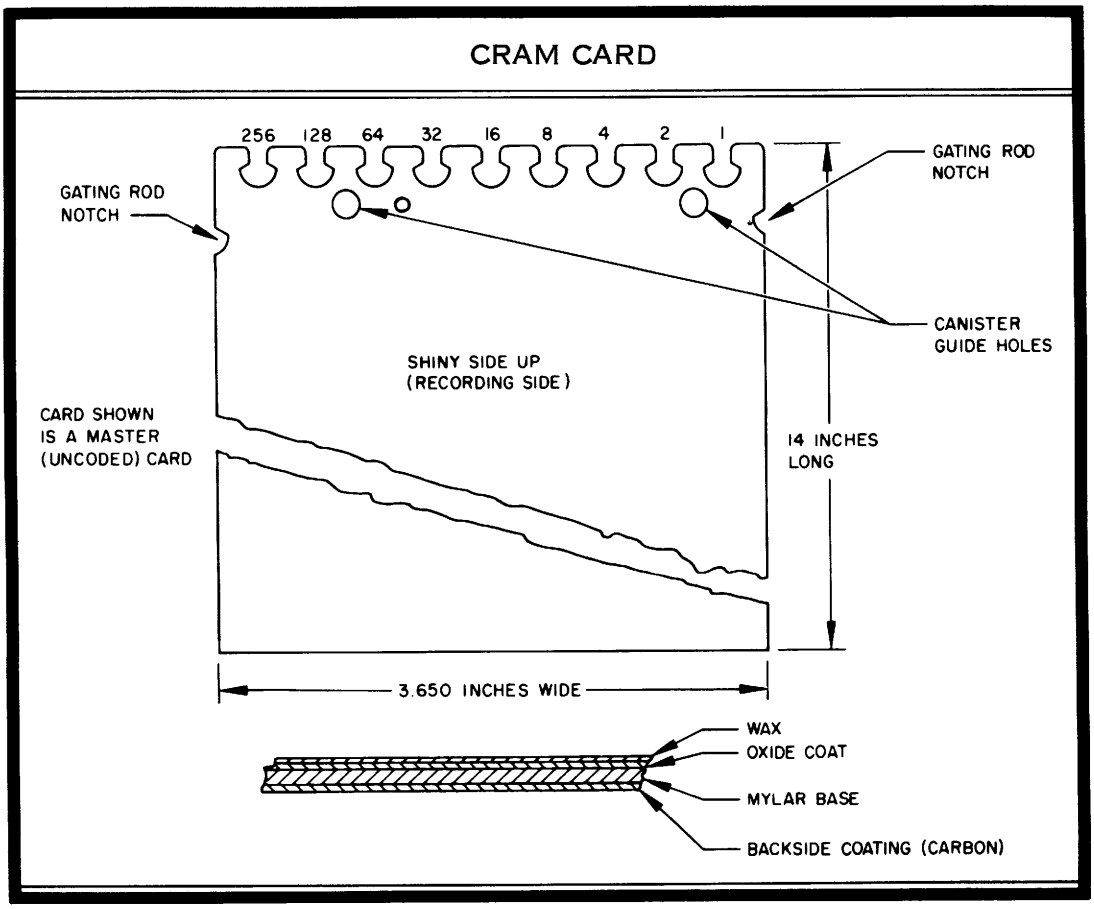




The loader plate moves to the left moving the card onto the selection rods.

MEDIA DESCRIPTION

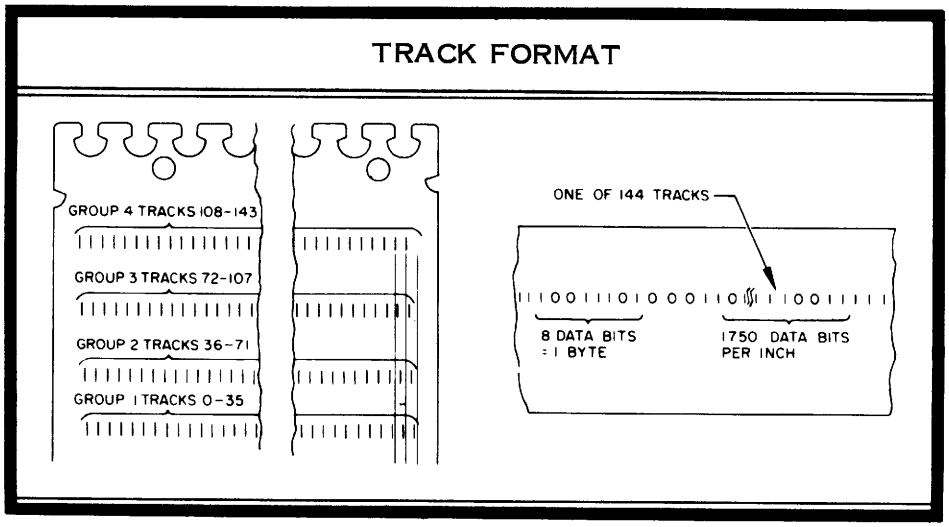
The recording media used on the CRAM unit is a multi-coated, mylar-base card approximately .005 inch thick. One side has a coating of carbon to help dissipate static electricity (this is to prevent cards adhering to each other in the magazine). The other side is coated with an oxide material with an overlay of wax. This side is the magnetic, or recording side of the card. The magnetic cards are 14 inches long and 3.650 inches wide. Approximately one inch at the leading edge and one inch at the trailing edge of the card are not used for recording data.



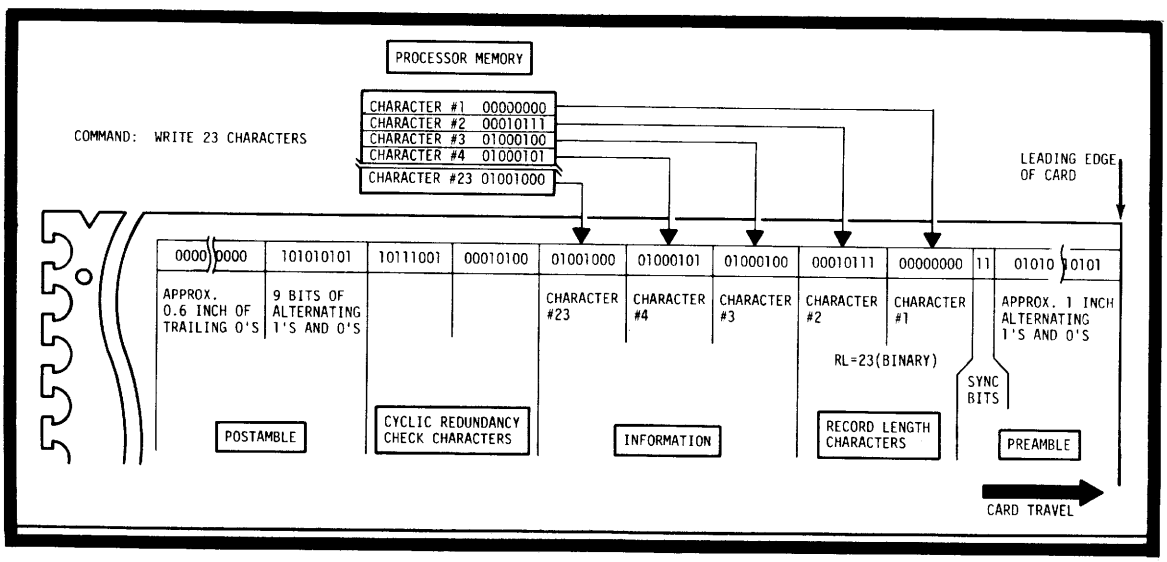
CRAM Media Characteristics

The write head accomplishes recording by magnetic induction. The write head, an electromagnet, causes the portion of the CRAM card that is in contact with the head to become magnetized. When a 1 bit is to be written on the CRAM card, current flows in the write head windings causing a miniature magnet to be induced onto the oxide of the card. A 0 bit is written the same way except the polarity of the magnet that is induced onto the oxide is in the opposite direction. The 653-101 uses the phase modulation scheme of recording. In this method of recording any time there are like data bits in succession a bit of the opposite polarity is written between them. These bits are called phase bits. There can be a maximum of 2623 bytes (8 data bits per byte) per track

on the CRAM Card. There are 144 tracks per card, numbered 0-143 and interlaced as four groups of 36. There are 384 Cards, numbered 0-383, per deck.


TRACK FORMAT
GROUP 4 TRACKS 108-143
GROUP 3 TRACKS 72-107
GROUP 2 TRACKS 36-71
GROUP 1 TRACKS 0-35
ONE OF 144 TRACKS
8 DATA BITS = 1 BYTE
1750 DATA BITS PER INCH

When a write command is issued by the processor the CRAM unit writes a preamble for approximately one inch from the leading edge of the card. The preamble consists of alternating 1-0 bits to the sync bits (two 1 bits). Following the sync bits, the data from the processor is written. The first and second characters, in true binary, represent the record length. The record length is the number of characters, from 4 to 2623, in the record, including the two record length characters. After the record is written, two CRC (cyclic redundancy check) characters are written. These two characters are not included in the record length. The CRC characters are made up by hardware in the CRAM control unit. This is the method used to check for a read or write error; that is, a dropped or picked-up bit. After the CRC characters are written, the postamble is written. The postamble is a pattern of alternating 1-0 bits for 9 bits and then 0 bits for approximately 0.6 inch further.



FUNCTIONAL DESCRIPTION

I/O REQUIREMENTS

A CRAM system is defined as a 623-201 CRAM control unit and a 653-101 CRAM unit. The executing of all I/O operations of a CRAM system involves:

- An Inout Command
- A Peripheral Address Field (PAF)
- An S2 Status Character

} SELECTION

- A Response Number
- A Control Word

} DATA TRANSFER

- An S3 Status Character

} TERMINATION

The selection phase includes selecting a designated CRAM unit, specifying a function to be performed by the CRAM unit, and actuating certain control lines to the processor to cause an S2 status character to be stored representing the results of the selection phase.

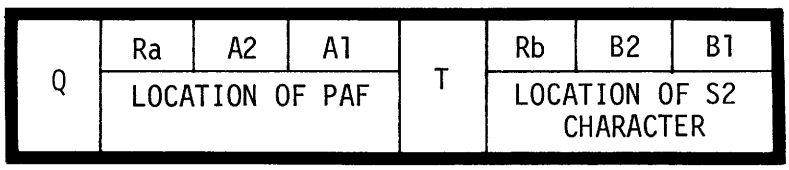
During data transfer the CRAM unit interrupts the processor when it is ready to perform the function that was specified in the selection phase. A response number is sent to the processor by the CRAM control unit to select the particular control word (CW) that is assigned to the CRAM unit. The control word includes the address of the pickup field for a write function or the putaway field for a read function.

The termination phase includes the generation and transmission of an S3 status character to the processor to be stored in the control word. This 8-bit character reflects the results, either successful or unsuccessful, of the data transfer phase.

SELECTION

INOUT Command

The 8-character INOUT command is used to select the CRAM control unit and the CRAM unit, specify the function to be performed by the CRAM unit, and store the S2 status character, which reflects the result of the selection.

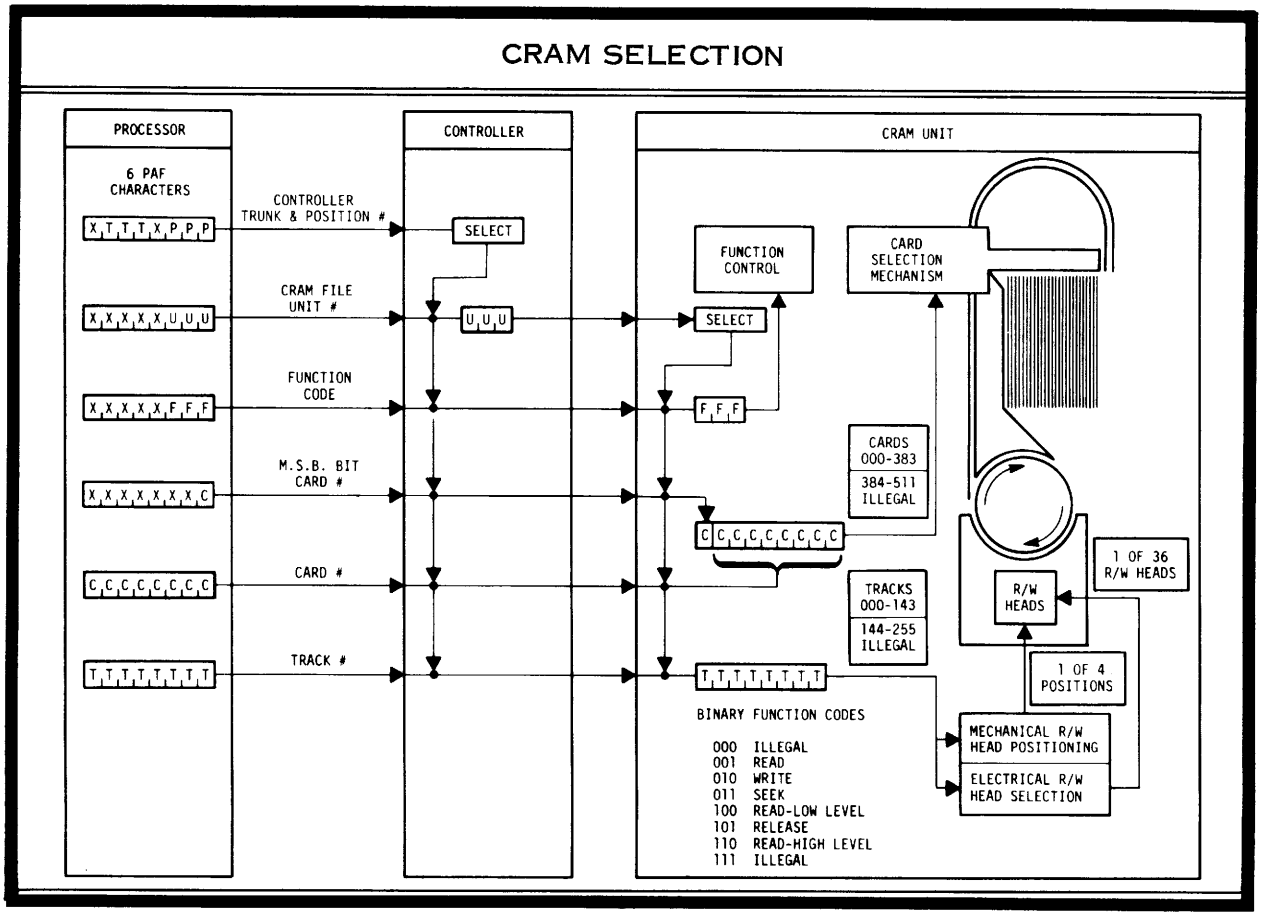


Q = 112 (command code for INOUT Command)
A = Address of PAF
T = Not Used
B = Storage address for the S2 Status Character

} Binary

Peripheral Address Field (PAF)

The CRAM PAF is a 6-character field of control characters addressed by the INOUT command. The processor sends each PAF character in sequence to select a CRAM control unit, select one of the CRAM units assigned to the control unit, specify the function to be performed by the CRAM unit, and specify the card and track number for the selected CRAM unit. During the execution of the INOUT command, the processor sends one PAF character at a time and then waits for the proper response before sending another. Failure of the control unit to respond to a PAF character causes the processor to store an S2 inoperable status character and terminate the INOUT command.



CRAM P A F CHARACTERS

#	CHARACTER 8 7 6 5 4 3 2 1	FUNCTION	BINARY VALUE	# OF BITS
1	X T T T X P P P	T=COMMON TRUNK # P=CONTROLLER POSITION #	0-7 0-7	3 3
2	X X X X X U U U	U=CRAM UNIT #	0-7	3
3	X X X X X F F F	F=FUNCTION CODE	0-7	3
4	X X X X X X X C	C=M.S. BIT OF CARD #	000-383 384-511 ILLEGAL	9
5	C C C C C C C C	C=CARD #		
6	T T T T T T T T	T=TRACK #	000-143 144-255 ILLEGAL	8

Function Codes

CRAM FUNCTION CODES		
0	(000)	Illegal
1	(001)	Read
2	(010)	Write
3	(011)	Seek
4	(100)	Read - low level
5	(101)	Release
6	(110)	Read - high level
7	(111)	Illegal

- Read

  Code 00000001 selects a CRAM unit, drops the selected card, positions the read/write head mechanism to the selected track while the card is dropping, waits for the card to be positioned in the read area, and then interrupts the processor to accept the data via the control unit and the common trunk.

- Write

  Code 00000010 selects a CRAM unit, determines that a card is already on the capstan and that this is the requested card, verifies that the head does not require repositioning for the requested track, waits for the card to get into writing position, and writes data from memory via the common trunk onto a magnetic card track. This function will not drop a card; a seek or read function must be used to drop the specified card.

- Seek

  Code 00000011 selects a CRAM unit, drops the selected card, positions the read/write head to the selected track while the card is falling, and terminate when an S3 character is sent. The controller sends an S3 status character to the processor approximately 2.0 milliseconds before the beginning of the card reaches the read/write heads. If the selected card is already on the capstan it will be kept on the capstan and the function will terminate when an S3 status character is sent.

- Read Low Level

  Code 00000100 is identical to read function code 00000001, except that the reading will be performed at a lower clipping level. This mode allows marginal one bits recorded on the magnetic card to be read in some cases, providing an extra margin of reliability. The read low level function should be employed only after a normal read has resulted in a read error.

The clipping level electronically regulates the sensitivity of the read circuitry. The lower the clipping level, the more sensitive the read circuitry will be. This level is variable to compensate for the differences in the strength of signal produced at the read head. If a record cannot be read at the normal read clipping level, then a read low level function could be performed to re-read the marginal record. At the lower clipping level, the read circuitry is more sensitive, decreasing the possibility of bit drop-outs in a marginal record. The clipping levels used are listed in decreasing order:

- The Read Check after write (least sensitive)
- Read High Level
- Read (normal)
- Read Low Level (most sensitive)

- Release

Code 00000101 selects a CRAM unit and causes it to release the CRAM card from the capstan for return to the card magazine. The control unit completes this operation when it transmits the function code to the CRAM unit, and does not wait for the actual release and loading of the card before sending the S3 status characters. If there is no card on the capstan, the S3 operation complete status character will still be transmitted.

- Read High Level

Code 00000110 is similar to the read function code (00000001) except that the reading is performed at a higher clipping level. This mode should be employed only after a write function has terminated with a write error. This function eliminates the errors from cross-talk which may occur during a write function when the read check is made while writing. Its only purpose is to make the read check with the write current OFF to see if this record can be read. No data is sent to the processor; only the S3 status character is sent.

S2 Status

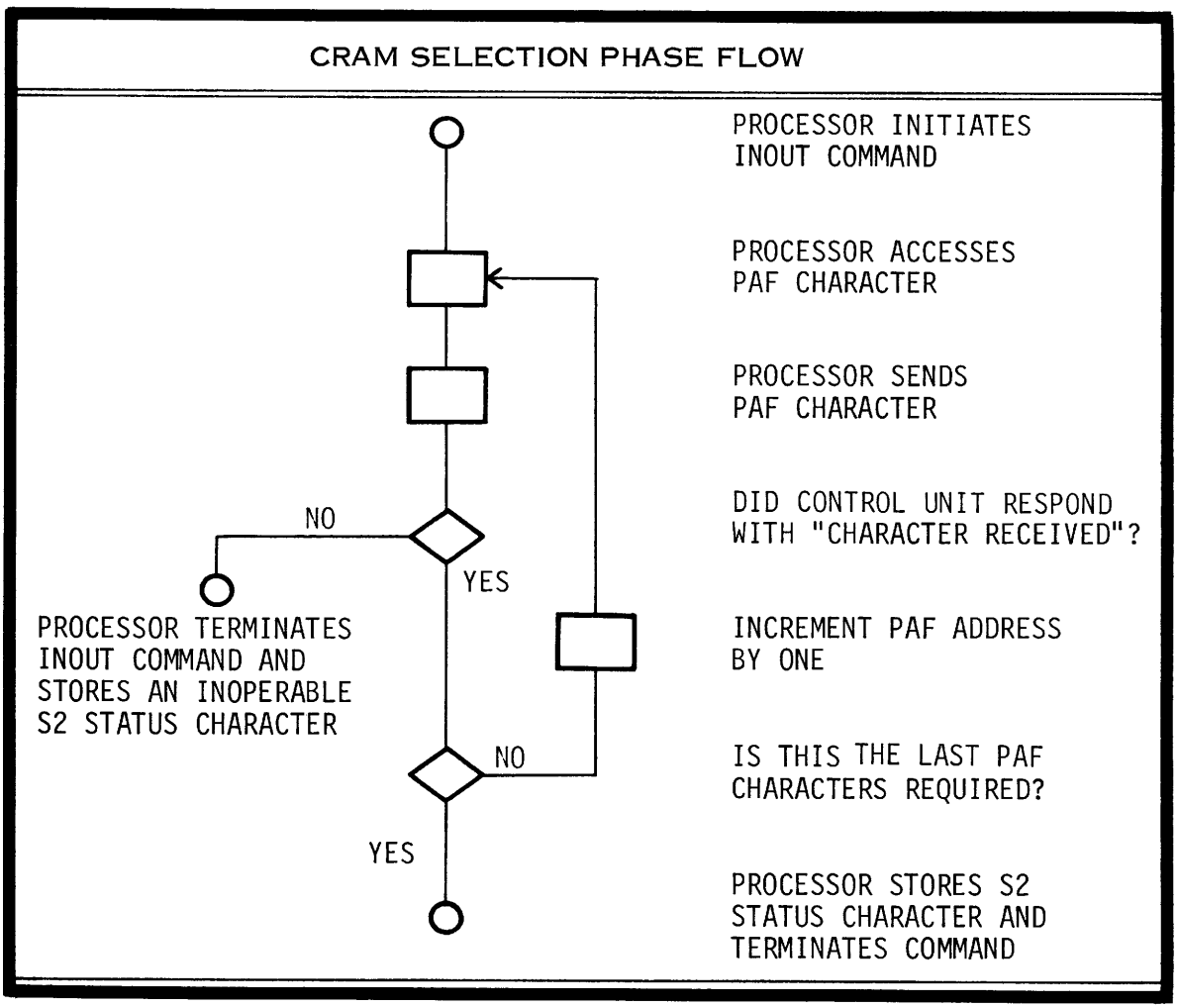
The S2 status character is stored by the processor prior to the termination of the INOUT command. This character reflects the results of the attempt to select and activate the CRAM unit designated by the PAF. This character is derived by the processor from the control lines of the controller and is not sent by the control unit itself. The control unit indicates one of four conditions when selection is attempted. The four S2 status characters are listed in order of their priority in the table on the following page.

CRAM S2 STATUS CHARACTERS		
CHARACTER	NAME	CONDITION
10000000	BUSY	Indicates an attempt is made to select a CRAM unit which is already in the selected state.
10000010	STANDBY	Indicates the CRAM unit is in the standby state when selection is attempted.
00000010	INOPERATIVE	Indicates either the control unit or the CRAM unit is inoperative. This condition may occur if: The control unit or the selected CRAM unit has a malfunction or is in the test state. An illegal function code is issued. The CRAM unit does not have WRITE PERMIT on for a write function. A function is issued to drop a card on a CRAM unit which still has a hanger condition from a previous function. A hanger condition is defined as failure of the selected card to drop.
01000000	COMMAND INITIATED	Indicates the CRAM unit is operative, the function code is legal, and the function will be started (successful selection).

Selection Phase Summary

The processor executes the INOUT command by sending the PAF characters one at a time to the control unit and CRAM unit. The control unit responds to the receipt of each PAF character by sending a character received signal to the processor. The control unit continues to request PAF characters until it has received the required number, at which time it signals the processor to derive and store the S2 status character and terminate the command.

If the control unit requests a PAF character and then fails to respond with a character received signal, the processor automatically stores an S2 inoperable status character and terminates the command.


CRAM SELECTION PHASE FLOW
PROCESSOR INITIATES INOUT COMMAND
PROCESSOR ACCESSES PAF CHARACTER
PROCESSOR SENDS PAF CHARACTER
DID CONTROL UNIT RESPOND WITH "CHARACTER RECEIVED"?
NO
YES
PROCESSOR TERMINATES INOUT COMMAND AND STORES AN INOPERABLE S2 STATUS CHARACTER
INCREMENT PAF ADDRESS BY ONE
IS THIS THE LAST PAF CHARACTERS REQUIRED?
NO
YES
PROCESSOR STORES S2 STATUS CHARACTER AND TERMINATES COMMAND

DATA TRANSFER

During the data transfer phase, the CRAM unit informs the I/O control when it is ready to perform the function specified in the selection phase. A response number is sent to the processor by the control unit to select the particular control word (CW) that is assigned to the CRAM unit. The control word directs the addressing of the pickup field during a write function or the putaway field during a read function.

Response Number

The control unit sends a unique unit response number, ranging from 0 through 63, (6 bit binary) to the I/O control section of the processor with each request for service. This binary number is derived from both the control unit and the CRAM unit. Its function in the processor is to specify the particular control word assigned to the file unit that originates the request.

UNIT RESPONSE NUMBER	
6 5 4 3 2 1 c c c u u u	c = Controller Unit Response Number (variable) u = CRAM unit number

The three high order bits (4, 5, and 6) of the unit response number are generated by the control unit; the three low order bits (1, 2, and 3) are generated by the CRAM unit. The control unit portion of the response number is wired into the control unit at the time of installation. This number is variable (000-111) and is distinct from the control unit number. The CRAM unit portion of the response number is not variable and will always be the same as the CRAM unit number.

Control Word (CW)

The control word is an 8-character field in memory used by the processor to control the specified operation of the selected CRAM unit. The processor computes the address of the CW from the response number sent by the control unit when service is requested. The CW specifies the pickup or putaway field, indicates when to terminate the operation, and accomodates the S3 status character.

Control words begin at fixed locations in memory starting at address 1024. The CW address can be computed from the formula CW = 1024 + (8N), where 1024 is the base address of the CW in memory and N is the response number sent by the controller.

EXAMPLE: Control unit sends a response of 21 (010101)

1024 + (8 x 21) = CW address

1024 + 168 = 1192

CONTROL WORD FORMAT							
S	NA			TA		X2	X1
	N3	N2	N1	T2	T1		

S = S3 status character storage area (1 character).

NA = Address of the next position in memory of the pickup or putaway field.

TA = Terminating address used in conjunction with NA to determine the end of the pickup or putaway field in memory. This in effect determines the size of the record that is read or written.

X_2X_1 = two characters available for software use.

TERMINATION

The termination phase includes generating and sending an S3 status character to the processor to be stored in the control word. This 8-bit character reflects the results, either successful or unsuccessful, of data transfer. This character is examined by the software, which then takes appropriate action depending upon the result.

S3 Status

When I/O operation is terminated (or initiated in the release function), the controller generates an S3 status character and sends it to the processor. This 8-bit character reflects the results of the I/O operation.

The release function, once initiated, can proceed offline, thus freeing the trunk for another I/O operation. In this case, the S3 status character is sent after the function is initiated but before the actual release of the card from the capstan.

CRAM S3 STATUS CHARACTERS

PRIORITY	CHARACTER 8 7 6 5 4 3 2 1	NAME	CONDITION
1	1 0 0 0 0 0 0 1	Transmission Error	A parity error detected by the controller on the incoming data (write)
2	0 0 1 0 0 0 0 0	Read or Write Error	A CRC character error (read or write) OR The RL does not equal the number of actual characters recorded on the card (read). OR NA - TA does not equal RL (write)
	0 0 0 1 0 0 0 0	System Overload	The processor did not respond to a request from the controller for character handling within the controller's character time (missed character)
	0 0 0 0 0 0 1 0	Inoperative	A malfunction in either unit after initiation of the function OR A hanger condition on a CRAM unit
	0 0 0 0 0 0 0 1	Illegal Write	During a write function there is NO card on the capstan, the WRONG card is on the capstan, or the read/write head is not in the required position for the specified track
3	0 0 0 0 0 0 0 0	Operation Complete	Successful completion of the operation

When multiple priority-2 status conditions occur during the same operation, the bits representing the conditions will be included in a single S3 status character and sent to the processor. Otherwise, the priority of status characters will determine which one is sent.

S3 Status Character Timing

S3 status characters will be sent to the processor at the following points in the function execution:

Read, write, read high level, and read low level are considered completed when the validity check characters are read and verified. At this time, the S3 character is sent to the processor, and the control unit terminates operation.

For a seek operation, the S3 character is sent when the magnetic card is in the minimum access position and the control unit is free to read or write on the card.

A release function may proceed offline after selection and initiation. At this time, the appropriate S3 character will be sent to the processor by the control unit.

S4 Status

An S4 status character, generated by the I/O control section of the processor, may be stored in place of the S3 status character. This 8-bit character is stored when any processor-detected error occurs. Additional data transfer is inhibited and deselection of the control unit is initiated. When a processor error occurs, the card remains on the capstan until the emergency release timer times out.

S4 STATUS CHARACTERS

CHARACTER 8	7	6	5	4	3	2	1	NAME	CONDITION
1	0	0	0	0	0	0	0	Transmission Error	Processor detected parity error (incoming character)
1	0	0	0	0	1	0	0	*Latent M E	Processor memory error
1	0	0	0	1	0	0	0	*Latent P E	Programming error

* NCR Century 200 Processor

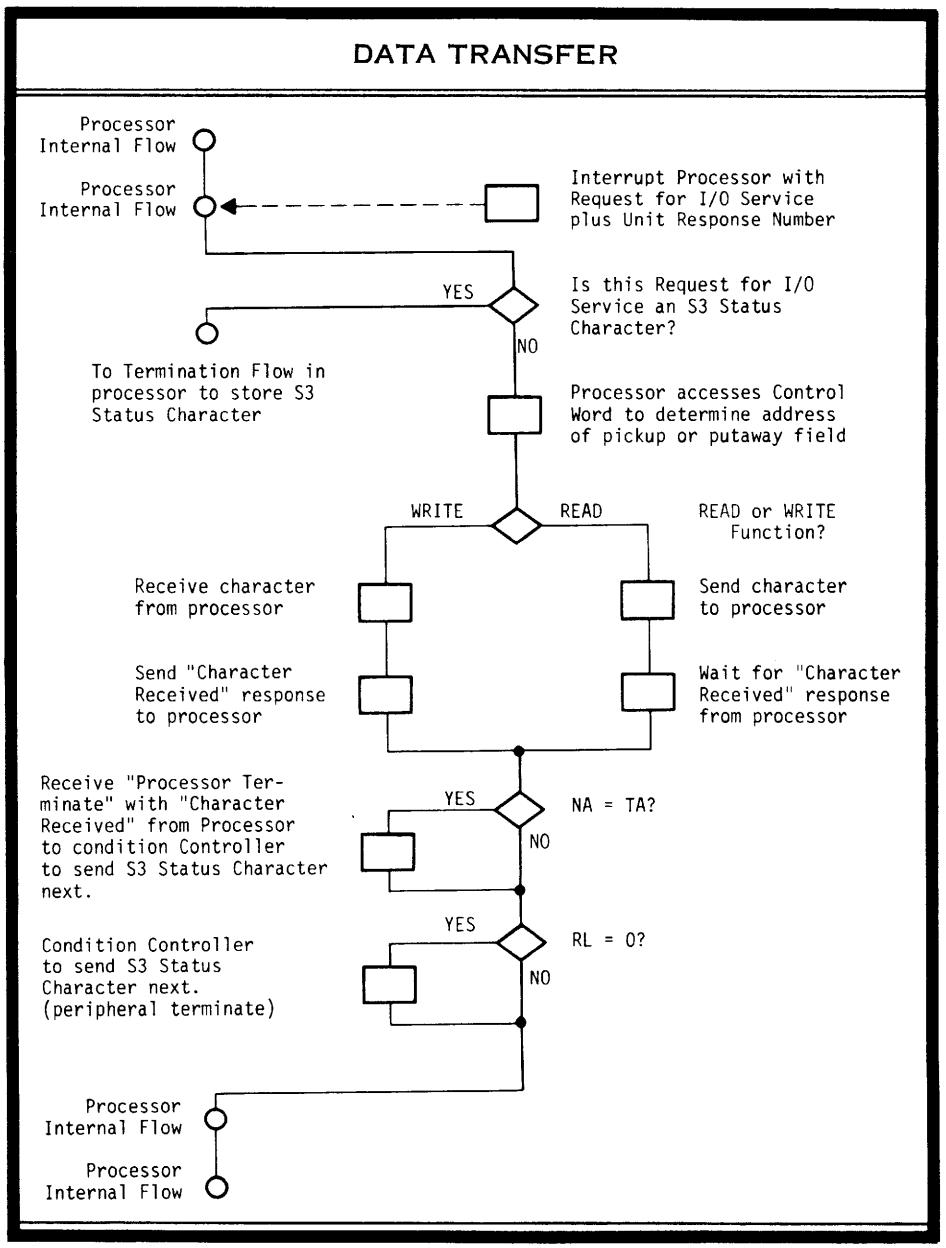
If a memory error or programming error occurs while the NCR Century 100 processor is servicing an I/O request, the control unit is deselected, an error trap is taken, and no status is stored in the control word.

Data Transfer and Termination Phase Summary

The CRAM unit notifies the control unit when it is ready to perform the function specified by the INOUT command. The control unit in turn interrupts the internal flow of the processor with a request for I/O service. The response number accompanies this request to the processor and determines the pertinent control word for this operation.

When the processor honors the I/O request, the control lines from the control unit are examined to determine if the I/O request is for status or data character transfer. If the request for service is an S3 status character, the processor executes the termination flow to store the status character. If the request for service is for data transfer, the pertinent control word is accessed. The data character is then transferred to the control unit for a write function or from the control unit for a read function.

Termination conditions are checked upon completion of the data transfer. If the processor has received (read) or sent (write) enough characters to satisfy the command (NA = TA), the processor sends a processor terminate signal to the control unit to condition it to send an S3 status character. If the control unit has sent all the characters that the record contains (RL = 0), it conditions itself to send an S3 status character.


DATA TRANSFER
Processor Internal Flow
Processor Internal Flow
Interrupt Processor with Request for I/O Service plus Unit Response Number
YES
Is this Request for I/O Service an S3 Status Character?
NO
To Termination Flow in processor to store S3 Status Character
Processor accesses Control Word to determine address of pickup or putaway field
WRITE
READ
READ or WRITE Function?
Receive character from processor
Send character to processor
Send "Character Received" response to processor
Wait for "Character Received" response from processor
Receive "Processor Terminate" with "Character Received" from Processor to condition Controller to send S3 Status Character next.
YES
NA = TA?
NO
YES
RL = 0?
NO
Condition Controller to send S3 Status Character next. (peripheral terminate)
Processor Internal Flow
Processor Internal Flow

PHYSICAL SPECIFICATIONS	
	CRAM UNIT
AC INPUT	3 PHASE 5 WIRES 10 AWG 120/208 60 HZ
KVA	5.2
KW	3.88
PF	0.75
BTU/HR	13200
CURRENT BY LEG	1 = 15 2 = 15 3 = 15
TOTAL CURRENT AT NOMINAL VOLTAGE	TURN ON = 240 AVER. OP. = 45 MAX. OP. = 45
CIRCUIT BREAKER	3 POLE 20 A.
DIMENSIONS HEIGHT WIDTH DEPTH WEIGHT	 66 INCHES 32 INCHES 27 INCHES 685 POUNDS
ACCESS REQUIRED FRONT REAR	 3 FEET 3 FEET
CONVENIENCE OUT.	NONE
AIR FLOW	BOTTOM TO TOP

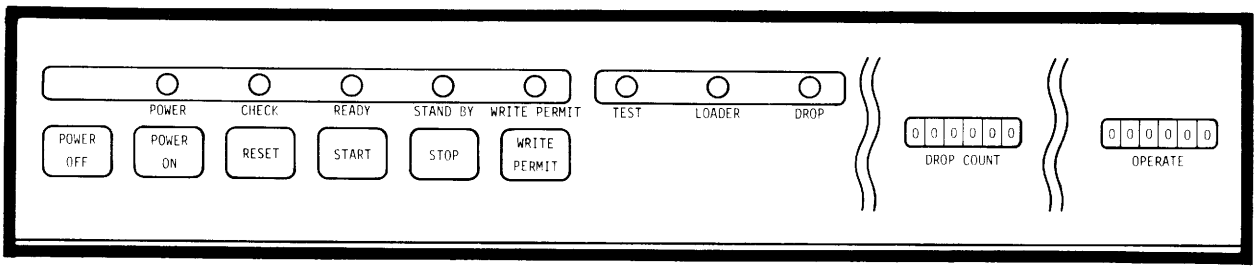
The required environmental conditions for the NCR 653 CRAM Unit are the same as they are for the NCR Century System with which it is used.

OPERATING LIMITS	
Temperature	68° to 78°F. Dry Bulb
Humidity	40% to 60% Relative
Altitude	7000 feet maximum

OPERATION

CONTROL PANEL

The operator control panel contains six switches, eight indicators, a drop counter, and a billing time meter.



CONTROLS AND INDICATORS	
SWITCH OR INDICATOR	FUNCTION
POWER ON	Lights when pressed. Actuates the sequencer causing sequential application of power in unit.
POWER OFF	Actuates the sequencer causing sequential removal of power in unit.
RESET	Clears all resettable errors. Should be momentarily pressed after a malfunction occurs to prepare CRAM for either the ready state or the test state. Releases the card from the capstan if it is held there due to any error.
	This switch should be pressed only momentarily as the loader does not function while it is pressed.
START	Attempts to put the CRAM unit into the ready state. If unit is in the standby state and cannot enter the ready state, it remains in the standby state.

CONTROLS AND INDICATORS [CONT' D]	
SWITCH OR INDICATOR	FUNCTION
START (cont'd)	If unit is in the test state, the stop switch must be pressed first to put the unit in the standby state. Pressing the start switch then causes the unit to enter the ready state.
STOP	Causes the unit to leave either the ready or test state and enter the standby state.
	If the unit is performing a function when the switch is pressed, the function is completed and an S-3 status character is generated and sent before the unit enters the standby state. This switch is the only way the unit can enter the standby state.
WRITE PERMIT	Closes the switch between the write current power supply and the center tap of the write heads.
	This switch must be pressed prior to performing a write function.
	The stop switch must be pressed before pressing the WRITE PERMIT switch to insure that the unit is in the standby state before the circuit is closed.
POWER	Lights when power is applied to the unit.
CHECK	Lights to indicate that a mal-function has occurred in the unit.

CONTROLS AND INDICATORS [CONT' D]	
SWITCH OR INDICATOR	FUNCTION
READY	Lights to indicate the unit is ready to perform a function.
STANDBY	Lights to indicate that the unit is in the standby state and cannot be called upon to perform an operation.
WRITE PERMIT	Lights to indicate that the switch to the center taps of the write heads has closed (unit can perform a write operation).
TEST	Lights to indicate that the unit has been placed in the test state.
LOADER	Lights to indicate that a loader malfunction occurred and operator intervention is required to complete loading.
DROP	Lights to indicate that a hanger condition exists and operator intervention is required.
DROP COUNT	Non-resettable 6-digit counter that indicates the number of cards dropped by the unit.
OPERATE	Used as a billing time meter. Registers up to 9999.99 hours.

CONTROLS AND INDICATORS [CONT'D]	
SWITCH OR INDICATOR	FUNCTION
OPERATE (cont'd)	Accumulates time when the CRAM unit is busy and the operate-maintenance key on the central processing unit is in operate. Registers a minimum of 100 milliseconds each time it is started.

POWERING UP THE CRAM UNIT

To put the CRAM unit in the ready state for online operation, perform the following sequence:

1. Press the POWER ON switch to apply power to the unit and light the POWER indicator. At this point, either the START switch or the WRITE PERMIT switch may be pressed.

2. If the START switch is pressed, the unit becomes ready and the READY indicator lights. The unit can now perform all functions except the write function.

3. If writing is desired, the WRITE PERMIT switch must be pressed. The WRITE PERMIT indicator should light. The START switch must then be pressed to put the unit in the ready state. The READY indicator will light.

4. If, during normal online operations, the mode of operation is to be changed, the STOP switch must be pressed to put the unit in a standby state. The standby state permits the WRITE PERMIT to be turned ON or OFF, or permits the unit to enter the test state.

5. If during a normal online operation a loader failure occurs, both the LOADER and the CHECK indicators light. To clear the loader error condition, the card that created the loader error must be manually moved into the loader and loaded on the selection and gating rods. At this time the RESET switch should be pressed. This action clears the error condition and turns off the indicator lights. The unit then returns to the normal operating state with the READY indicator lighted.

POWERING DOWN THE CRAM UNIT

Press the POWER OFF switch. This action removes the CRAM unit from the ready state and sequentially removes power from the unit.

If a card should be on the capstan when the POWER OFF switch is pressed, the card is released from the capstan and loaded. The CRAM then proceeds to down sequence.

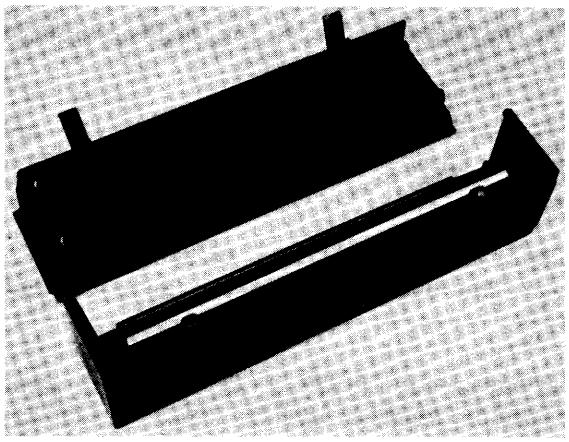
LOADING A CRAM DECK

The CRAM card deck shipping and storage container is a dual-purpose device that provides a means for loading the CRAM cards into the CRAM unit and also acts as a storage container for the CRAM card deck. Correct use of this container not only simplifies the operation of loading the deck into the CRAM, but also minimizes the physical handling of the deck.

1. Release the two catches and remove the cover.

NOTE

When removing the cover, notice the manner in which the container and the cover are interlocked. This will aid in replacing the cover quickly.

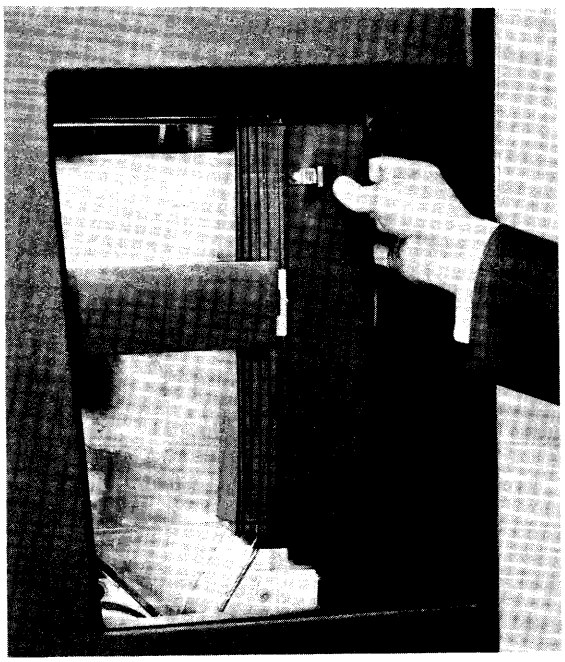


2. Remove and discard the foam shipping pads.

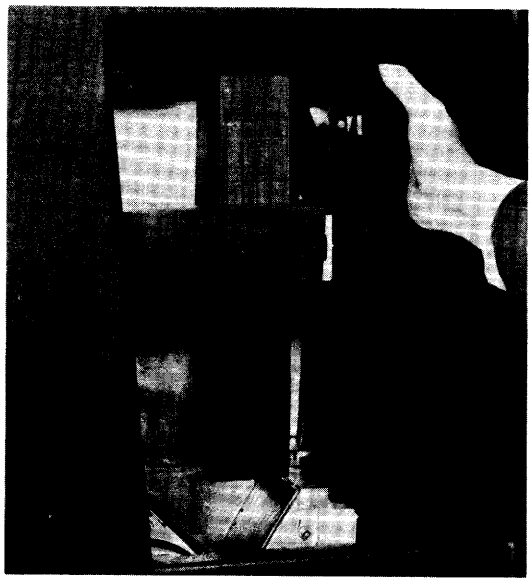
3. Examine the container. Notice the two round peg extensions on the lower portion. These pegs mate with a matching area on the CRAM unit to align the cards with the selection rods.

4. Open the CRAM loader door. Holding the card container as shown in the illustration, insert the top end first in order to clear the overhead obstruction.

5. Swing the lower end in and place it down over the drop ramp so that the peg extensions mate with the holes in the ramp assembly.



6. Rotate the top end toward the selection rods so the exposed raceway end tab bottoms against the container.



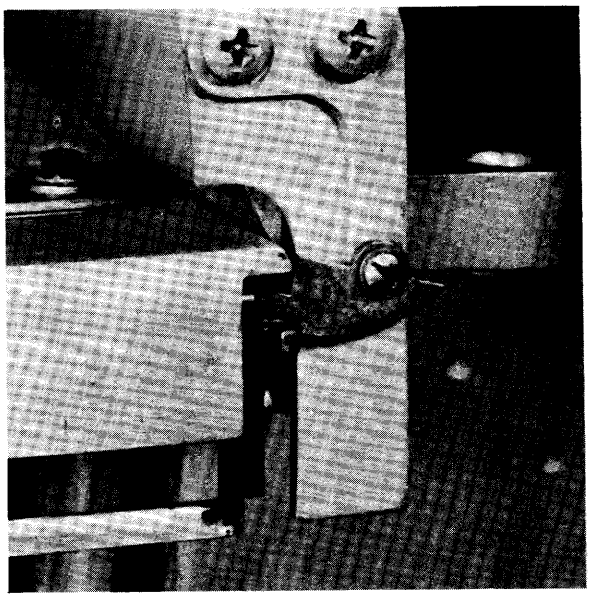
7. While holding the container firmly in this position, slide the deck off the guide pins and onto the selection rods by pressing the hinged pusher plate through the back opening of the container. Move the cards onto the selection rods.

8. Remove the empty container by reversing the loading procedure. Replace the cover on the container.
   The CRAM unit is now ready for operation.
   Press the POWER ON switch.
   Press either the START switch or the WRITE PERMIT switch.
   If writing is desired, press the WRITE PERMIT switch, then press the START switch to put the CRAM into the ready state.
   If no writing is to take place, press only the START switch. The READY indicator lights and the CRAM is ready to perform normal on-line functions.

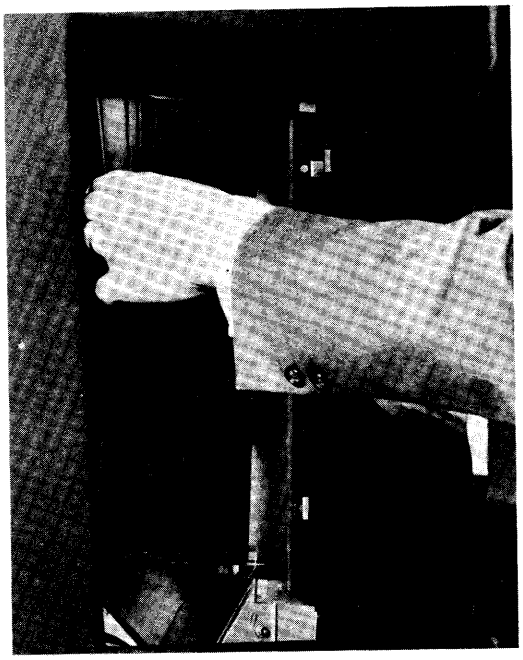
CHANGING CRAM DECKS IN A CRAM UNIT

The changing of CRAM decks may be performed without powering down the CRAM unit. This operation can be performed because the plenum air, which normally separates the cards, is shut off when the loader door is opened.

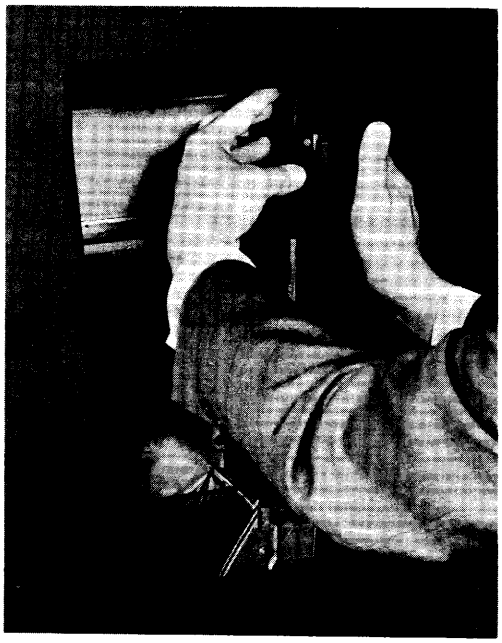
1. Remove the cover of the empty container and place the container into position as explained under the loading operation. Hold the container firmly in position with the right hand.



2. Examine the locking latch to see if the container released the latch. If the locking latch has not released the card retainer mechanism, the cards cannot be moved into the container.



3. With the left hand, feed the cards back onto the container guide pins. If any resistance occurs, re-examine the locking latch.



4. Remove the loaded container by reversing the loading procedure. Replace the container cover and secure the two latches. The CRAM card deck can now be placed into storage.

CAUTION

Do not place CRAM card decks on top of or between CRAM units or on the high speed card reader. There is the possibility of destroying the recorded information by exposing the cards to strong magnetic fields.

CRAM DECK MAINTENANCE

One of the advantages of the CRAM system, as opposed to magnetic tape, is that the wear in an individual section need not mean a reduction in the efficiency of the package, since individual cards can be replaced. To maintain CRAM decks in the most economical manner, all decks should be examined periodically and purged of bad cards. Purging should be a regularly scheduled procedure, performed under good lighting, with the date of purge either entered in a log book or written on the deck's yellow card. After each purge, a date should be set for the next purge of that deck; this date should be set by the customer's operator, who should base his decision on expected usage, type of usage (random, sequential, etc.) and current state of wear. While the operator is inexperienced in this he may be assisted by NCR site personnel, but the final decision in all card replacement matters must be made by the operator. The grounds for replacing a card will be either tab wear or damage, or surface wear or damage.

Inspection of Tabs

If any tab on a CRAM card is weakened to such an extent that it cannot support the card by itself, then there will be a second card in the deck, which, if called for, will come down accompanied by the defective card in a double drop. Since normal tab wear is a gradual process, it is generally possible to anticipate such a failure and replace the card before the failure occurs. Because of the large number of tabs in a deck (3840), it is timesaving to perform the visual check as a routine procedure, with an awareness of the types of wear that can occur. These are as follows:

- Oxide Flaking

  A type of wear that is visually prominent but not actually harmful is the chipping off of particles of oxide in the tab area. This causes a visible change in the tabs but does no damage, since the oxide in this area is not written on and does not contribute to the structural strength of the tab.

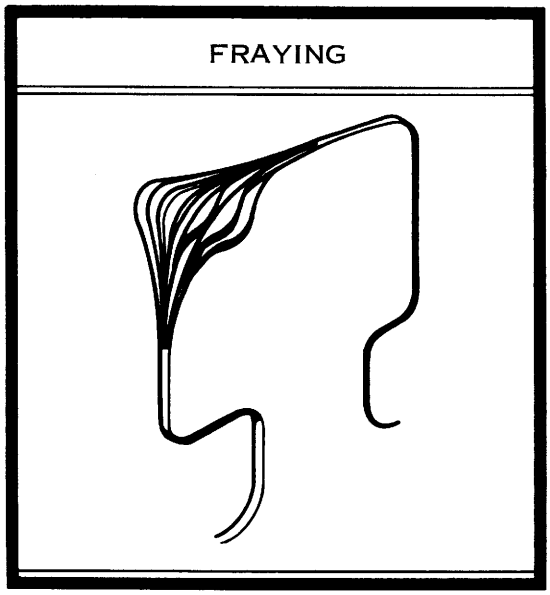
  Oxide is present in the tab area only because of the method of manufacture.

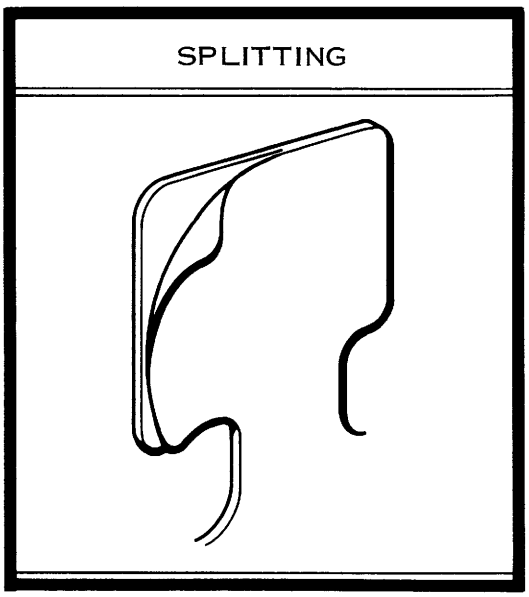
  The oxide flaking should normally occur only during the first 5 to 25 drops of a new card. Special care must be taken to clean the CRAM unit thoroughly during the initial use of these cards.

- Separation

  Under repeated impact, the base material may separate into layers. The cards may be either split or frayed (see illustration on page 42).

  Separation does not by itself weaken the tab to a point of failure, but in its advanced stages the laminations may tear off separately until the tab is no longer able to support the card.



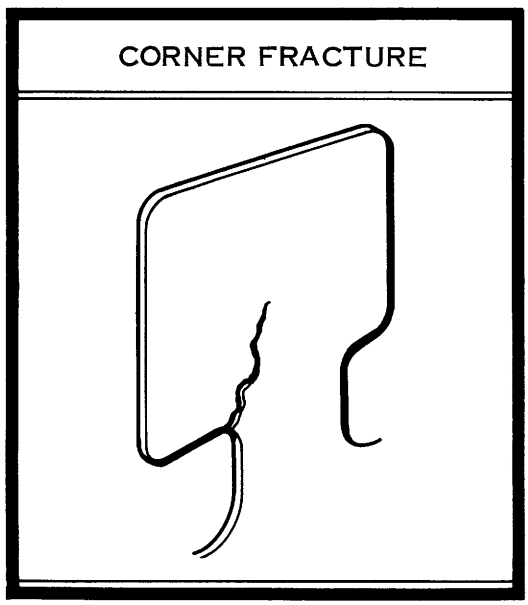


Fraying is easily observed, since it increases the cross section of the tab. If many cards in one deck suffer from this type of wear, the tab portion of the deck will be appreciably thicker.

Splitting is not as evident, but is potentially more serious, since the loss of a single section can destroy the effectiveness of the tab.

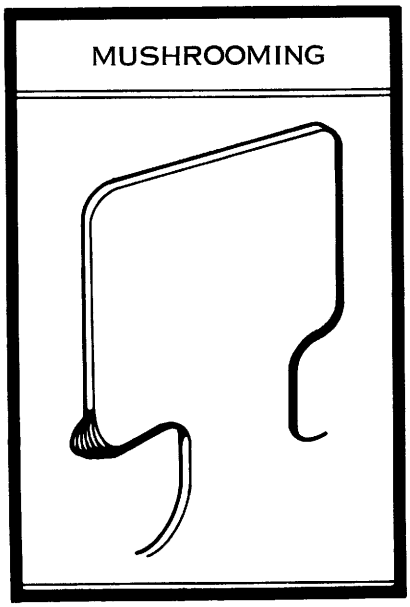
- Corner Fractures

This type of wear occurs while the card is in the magazine and can ultimately cause a tab failure even in a card that has never been dropped. The fracture starts near a corner and enlarges very slowly, over many thousands of machine cycles. However, if the card is also being dropped, development of the tear can be accelerated by impact against the drop ramp.



- Mushrooming

  Sometimes the angle at which the tab strikes the drop ramp starts a limited exfoliation at the bottom of the tab. This wear does not indicate a double drop condition; however, it can cause slow drops and hangers. Therefore if a card has been involved in repeated slow drops and exhibits mushrooming, it should be replaced.



- Bent Tab

  When a tab is bent slightly out of shape it is unlikely to cause a double drop, but may cause load failures by slowing down the card as it moves around the raceway. If such a tab can be straightened out without appreciably weakening it, the card can be reinserted in the deck.

Inspection of Surface

Although a dropout may frequently be visible to the eye after its location on the card has been identified by read/write performance, it is rarely possible to predict dropouts by visual examination. For this reason it is not usually fruitful to inspect the surfaces of cards except those that have been flagged by the program as containing permanent error. Before replacing the card, the defective area should be closely examined since, in many cases, a particle that has adhered to the surface can be brushed off, correcting the difficulty.

To clean a card, place it on a clean, flat surface. Dampen a soft, clean, lint free cloth with NCR silicone wax (part number 603-8000312). Wipe the card with light even strokes, running from end to end. Expose a clean portion of the wiping cloth with each stroke.

DO NOT use anything other than NCR silicone wax to clean CRAM cards.

Operation Procedures

Deck maintenance should not be performed on decks containing live information.

It is recommended that the full deck be initialized after replacing defective cards, but if time is of the essence, only the cards replaced and card 000 (skip directory) may be initialized.

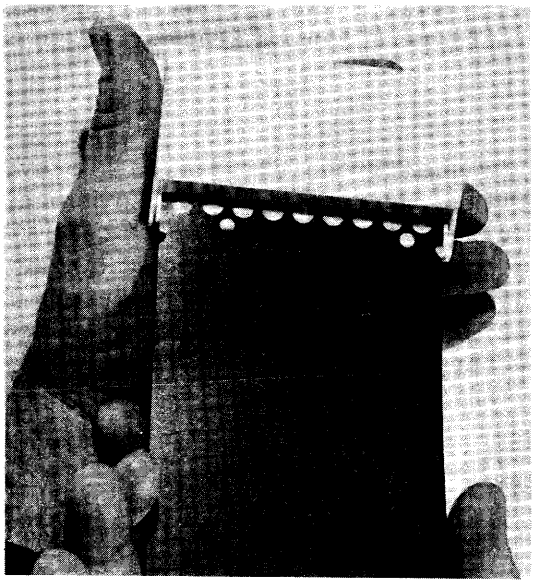
A log of some type should be kept for the decks on site so that a regular maintenance schedule may be set up.

CRAM Card Coding Procedure

A CRAM card coder kit (part number 315-0502775) is available to customers. The kit is a small hand-operated device which provides a means of on-the-site coding of individual cards. The kit consists of a Card Coder Assembly (part number 315-0502771) and the CRAM Card Punch (part number 353-26900). The coder may be used in two ways: by directly copying the notch pattern of the card to be replaced or by referring to the card's binary code address as printed on the coder assembly label.

The CRAM Card Coder Kit should be used in the following manner:

- Loading Master Card Into the Coder

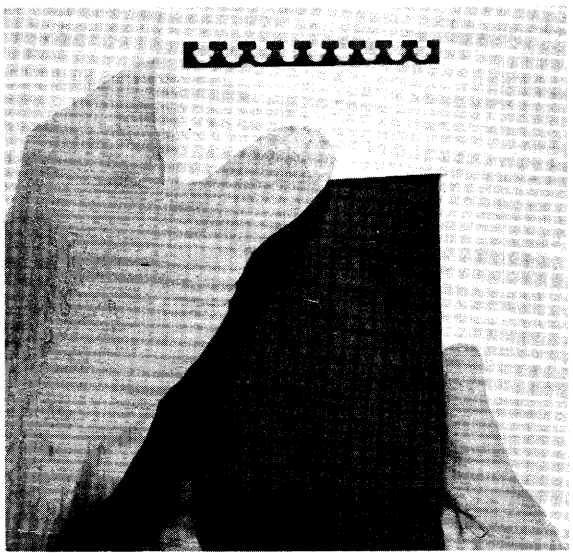


1. Hold the coder as shown with the lid in the open position.

2. Insert the master CRAM card into the coder assembly, shiny side up. Position card to the rear so that the gating key notches are aligned with the gating key tabs of the coder.

NOTE

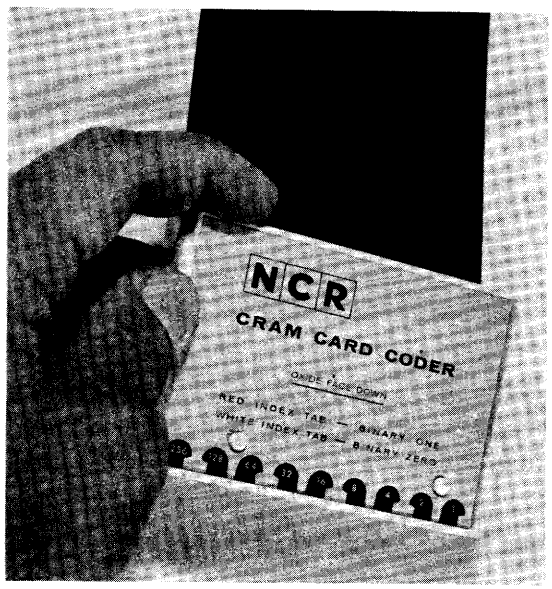
Use only a new card that has perfectly straight, flat tabs.



3. When the card has been seated properly, close the coder lid.

NOTE

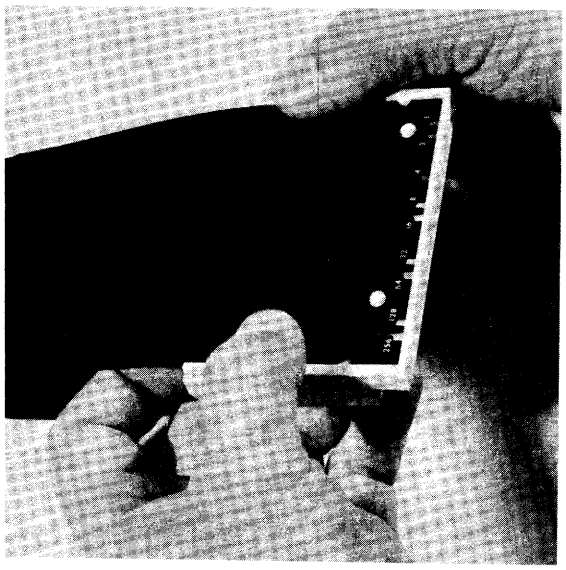
The different shape of the gating key notches and tabs will prevent the lid from seating properly if the card has been placed in the coder upside-down.



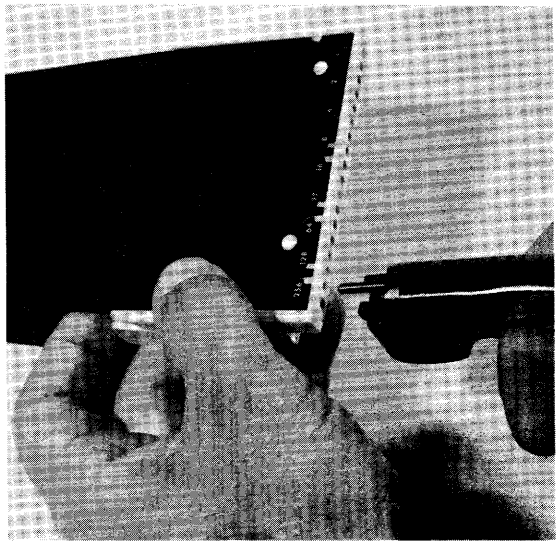
4. Holding the lid shut, invert the coder assembly so that the instruction label is up and readable.

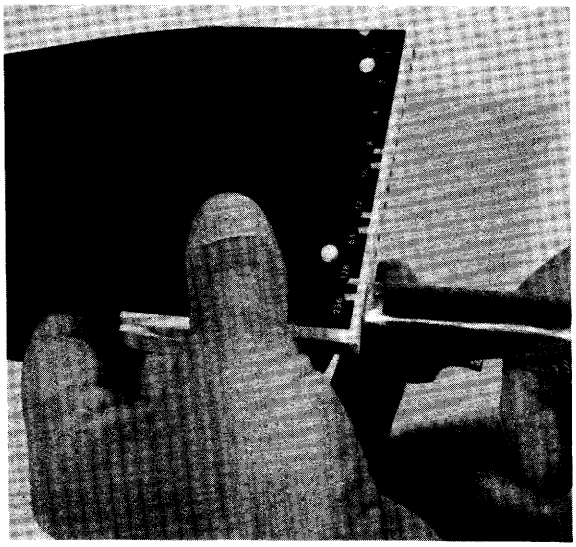
   The card is now ready for coding.

- Coding the Card by Copying the Card to Be Duplicated



1. Place the CRAM card to be duplicated over the printed label (dull side up) so that the tabs and the gating key notches are aligned with those printed on the label. The red and white tabs on the label which are exposed are the ones to be removed.





2. To remove the tabs, start at the left end of the card and insert the punch locating pin into the hole directly beneath the first exposed red or white label. Be sure the punch is fully inserted into the coder before making the cut. The scribe mark on top of the punch acts as a reference to insure that the punch has been inserted into the proper hole. Remove the first tab and proceed left and right removing the desired tabs.

3. After completing the cuts, open the lid and remove the newly coded card. Make a visual comparison of the tab area of the two cards by overlaying them. The new card is now ready for use.

- Coding the Card by Referring to the Binary Address

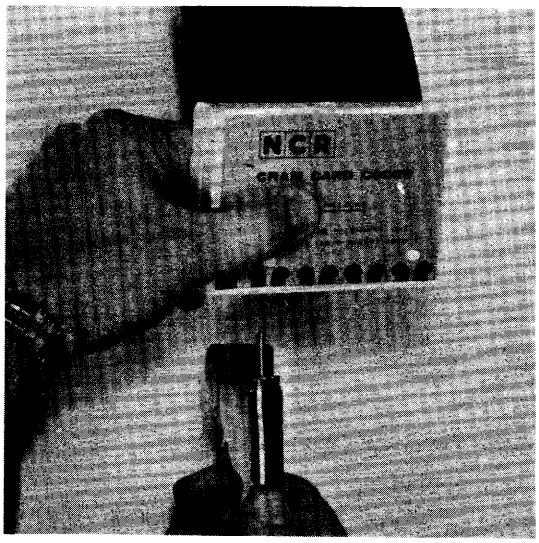
1. Determine the binary code address of the card to be coded from its decimal address.

   Refer now to the binary code numbers and tabs as they are printed on the coder label. The red and white index marks represent a binary 1 or a binary 0 for each column.

2. To remove the tabs, start at the left end and insert the punch locating pin into the hole which is directly beneath the desired red or white tab of the first column and make the cut. Follow the same procedure for columns 2 through 256.

NOTE

A red or white tab must be removed from each column.



3. Use the scribe mark on the punch for the final reference to be sure the punch has been inserted into the proper hole before making the cut. After completing the nine cuts, remove the card from the coder and place the printed label over the coder. The red tabs will indicate the tabs removed. The value of these red tabs added together will be the decimal value of the coded card.

NOTE

Care must be observed when handling CRAM cards. Scratches or marks on the cards must be avoided. The CRAM Card Coder is a precision instrument and must be handled with care.

The kit should be ordered on supply form F-3874. Orders should be sent to:

Service Parts Department
NCR-ED
Hawthorne, California

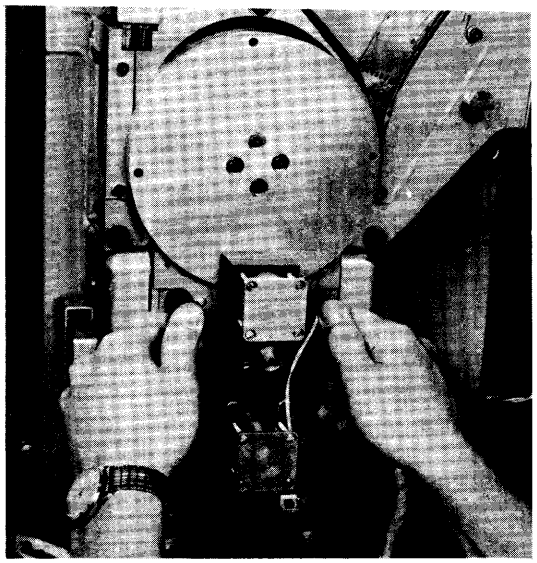
UNIT MAINTENANCE

Operator maintenance for the CRAM unit consists of normal and emergency maintenance.

Normal Operator Maintenance

Normal operator maintenance on the CRAM unit consists of cleaning the read/write recording surface. This is necessary because of normal oxide accumulation from the CRAM cards.

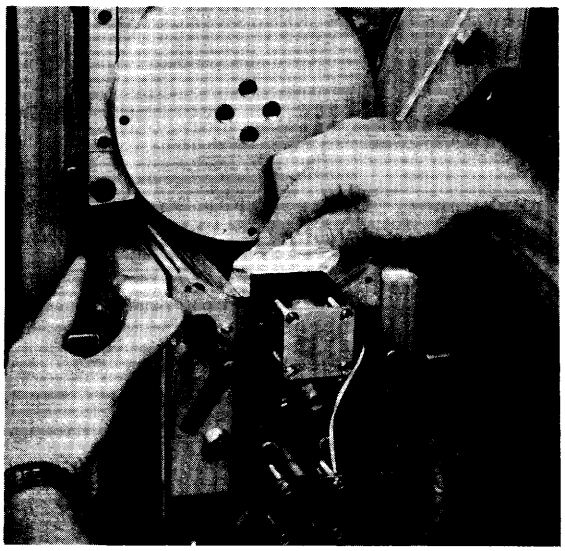
Cleaning should be performed every four hours of operation, after every 30,000 revolutions, or after a card jam on the head assembly. Clean the head as follows:



1. Grasp the handles on the front of the head assembly and press the buttons in the handles.

2. While holding the buttons in, remove the handles slowly. Maintain a good grip on the handles as the head assembly drops down to a lowered position where the handles are full out.

3. With the head lowered, slide the head to the full out position.



4. Clean the recording surface thoroughly by wiping with a Kimwipe dampened with freon or chlorothene to remove all oxide deposits.

NOTE

Use freon or chlorothene sparingly. Excess freon or chlorothene may cause damage to the internal structure of the head assembly.

Continually change the Kimwipe until it remains clean.

Emergency Operator Maintenance (Jams)

Emergency maintenance is required in two instances: card jams in the head assembly and card jams in the loader assembly.

- Head Assembly Card Jam

A card jam may occur in the head assembly when several cards enter the capstan head area simulatneously. This can occur when cards are inadvertently knocked off the rods or when duplicate cards exist in the deck.

1. When a card jam occurs, press the POWER OFF switch immediately.

2. When the capstan stops turning, lower the head and move it to its full out position as outlined in the head cleaning description.

3. With the head extended, reach in behind the head assembly and remove the cards from the capstan area.

NOTE

If any damage occurs to the CRAM unit, contact the local NCR technical services representative before attempting to correct the damage.

4. Examine the cards to determine the card damage if any. Code and replace the cards if necessary.

5. Clean the head recording surface as required according to the head cleaning technique.

6. After cleaning thoroughly, install the head assembly. Press the POWER ON switch and restore the CRAM unit to its operating state.

- Loader Card Jam

A loader card jam may occur when a card enters the loader while the loader is attempting to load another card. If a loader jam occurs and a card is on the capstan, the card remains on the capstan until the error is cleared and the RESET switch is pressed.

1. When a loader jam occurs, open the loader door carefully to prevent cards from being pulled off the selection rods.

2. When the loader door latch is turned, it removes the separator air from the top of the cards. With the loader door open, remove the cards involved in the jam.

3. Examine the cards involved for damage and replace as necessary.

4. When the jam is cleared and the cards returned to the magazine, close the loader door.

5. If a card is on the capstan, press the RESET switch to release and load the card. The unit now returns to a normal operating state.